Jackson, Susank

From:	Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent:	Monday, June 23, 2014 12:49 PM
To:	Jen.Stamp@tetratech.com; Gerritsen, Jeroen; Pond, Greg; Reynolds, Louis; Jackson, Susank
Cc:	Curtis, Meosotis
Subject:	FW: draft BCG report for the Northern Piedmont region of Maryland
Attachments:	NPied_BCG_report_20140530.docx; Append_A_CaseExamples.docx; Append_B_MoCoBCG.docx; Append_C_AttribBugs.docx; Append_D_AttribFish.docx; Append_E_BugDisturb.pdf; Append_F_FishDisturb.pdf; Append_G_SampleWkst.docx; Append_H_BugCalls.docx; Append_I_BugBoxPlots.pdf; Append_J_FishCalls.docx; Append_K_FishBoxPlots.pdf

Hi Jen and Jeroen:
Well, I find myself in a situation that I have rarely been in. I have no edits or comments on the work you all have produced. I would not change anything. I find the document and all the appendices to be well written, understandable and to the point. The listing of the species starting on page 5 of Appendix B was a great addition as it helps me envision the biological community associated with each tier within the piedmont. Thank you so much for all this work! You all went far above what I thought was going to be provided and I thank you.

Now I have to find something I can edit and comment on! Your work certainly doesn't require my 'bull in the china shop' editing approach. Now I would like to review the excel spreadsheets you sent over that can be used to calculate the BCG model outputs – I may have questions on that!

Sincerely
Keith Van Ness

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Thursday, June 12, 2014 9:35 PM
To: Pond.Greg@epa.gov; EFriedman@dnr.state.md.us; Warren.Smigo@deq.virginia.gov; William.Shanabruch@deq.virginia.gov; Ellen.Dickey@state.de.us; mstover@mde.state.md.us; mbaker@umbc.edu; NDziepak@dnr.state.md.us; Matthew.Harper@montgomeryparks.org; David.Sigrist@montgomeryparks.org; aeverett@pa.gov; cluckett@mde.state.md.us; Jeanne.Classen@deq.virginia.gov; aleslie@umd.edu; cmswan@umbc.edu; agriggs@icprb.org; Jordahl, Dave; Alexander.Laurie@epa.gov; SSTRANKO@dnr.state.md.us; Reynolds.Louis@epa.gov; Jcummins@ICPRB.org; msoutherland@Versar.com; abecker@dnr.state.md.us; Jai.Cole@montgomeryparks.org; cpoukish@mde.state.md.us; borsuk.frank@epa.gov; Mack, Kenny; JKilian@dnr.state.md.us; St. John, Jennifer; Van Ness, Keith; cgougeon@dnr.state.md.us; Naibert, Eric; Jackson.Susank@epa.gov; Shofar, Steven; Curtis, Meosotis; mary.dolan@montgomeryplanning.org; mark.symborski@montgomeryplanning.org; Forren.John@epa.gov; DBOWARD@dnr.state.md.us
Cc: Gerritsen, Jeroen
Subject: draft BCG report for the Northern Piedmont region of Maryland

Hello members of the Northern Piedmont BCG working group,
Attached you'll find the draft BCG report for the Northern Piedmont region of Maryland. If you have an opportunity to provide comments on the report, we welcome your feedback. If possible, we ask that you send us your comments by **Friday June 27.**

In addition, in a separate email I will send out Excel worksheets that can be used to calculate BCG model outputs for new data.

Please let me know if you have any questions about the attached files.

Thank you! We greatly appreciate your participation in this project,

Jen and Jeroen

Jen Stamp | Aquatic Ecologist
Voice: 802.229.4508 (office) 802.839.8603 (cell)| Fax: 802.223.6551 Jen.Stamp@tetratech.com

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Jackson, Susank

From: Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent: Wednesday, June 25, 2014 10:45 AM
To: Gerritsen, Jeroen; Jen.Stamp@tetratech.com
Cc: Jackson, Susank; [redacted]
Subject: RE: draft BCG report for the Northern Piedmont region of Maryland

Let me ask our IT people. Whatever is easiest for you would be my preference! I'll get back to you soon.

From: Gerritsen, Jeroen [mailto:Jeroen.Gerritsen@tetratech.com]
Sent: Wednesday, June 25, 2014 9:49 AM
To: Stamp, Jen; Van Ness, Keith
Cc: Jackson, Susank; [redacted]
Subject: RE: draft BCG report for the Northern Piedmont region of Maryland

Also, Keith, we have a mandate from Susan to get you a working calculation system (software) to calculate the BCG levels for new samples that Mo Co takes. This can be the Excel workbook that Jen already sent (modified to be user friendly as necessary), or we have an access application that we can modify for the MoCo /MBSS data.

What is MoCo's preference for this? How do you currently store and archive the monitoring data? If possible, we should set up a conference call or meeting to scope this out.

Thanks,

Jeroen

Jeroen Gerritsen
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From: Stamp, Jen
Sent: Monday, June 23, 2014 3:28 PM
To: Van Ness, Keith; Gerritsen, Jeroen
Subject: RE: draft BCG report for the Northern Piedmont region of Maryland

Hi Keith,
Wow that is excellent! I am so glad that you liked the report and didn't have any major edits.

I tried to make the Excel worksheets as simple as possible but unfortunately they are still complicated. Please let me know if the Instructions file needs to be improved.

Also, I wanted to follow up about your earlier email regarding the comparison of the IBI and BCG. I am glad you found that useful. We initially included those results in the report but then decided to pull that section out because sometimes comparisons like that get a bit touchy (sometimes people get into debates about which score – the IBI or BCG – is correct). Jeroen, do you have any further thoughts on that topic? Perhaps we'll reconsider if it comes up in other reviewers' comments.

Thanks,

Jen

From: Van Ness, Keith [mailto:Keith.VanNess@montgomerycountymd.gov]
Sent: Monday, June 23, 2014 12:49 PM
To: Stamp, Jen; Gerritsen, Jeroen; Pond.Greg@epa.gov; Reynolds, Louis; Jackson.Susank@epa.gov
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Calibration of the Biological Condition Gradient (BCG) for Fish and Benthic Macroinvertebrate Assemblages in the Northern Piedmont region of Maryland

DRAFT REPORT

***Prepared for*:**

USEPA Office of Water, Office of Science and Technology
Susan K. Jackson, Work Assignment Manager

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May 30, 2014

EXECUTIVE SUMMARY

The objective of the Clean Water Act is to "restore and maintain physical, chemical and biological integrity of the Nation's waters." To meet this goal, we need a uniform interpretation of biological condition and operational definitions that are independent of different assessment methodologies. These definitions must be specific, well-defined, and allow for waters of different natural quality and different desired uses. The US EPA has outlined a tiered system of aquatic life use designation, along a gradient (the Biological Condition Gradient, or BCG) that describes how ecological attributes change in response to increasing levels of human disturbance. The Biological Condition Gradient is a conceptual model that describes changes in aquatic communities. It is consistent with ecological theory and has been verified by aquatic biologists throughout the US.

Specifically, the BCG describes how ten biological attributes of natural aquatic systems change in response to increasing pollution and disturbance. The ten attributes are in principle measurable, although several are not commonly measured in monitoring programs. The gradient represented by the BCG has been divided into 6 BCG levels of condition that biologists think can be readily discerned in most areas of North America, ranging from "natural or native condition" (Level 1) to "Severe changes in structure and major loss of ecosystem function" (Level 6).

This report summarizes the findings of a panel of aquatic biologists from the Montgomery County Department of Environmental Protection, the State of Maryland, the University of Maryland, University of Maryland at Baltimore County, the Interstate Commission for the Potomac River Basin, US EPA and the states of Virginia, Pennsylvania and Delaware, who applied and calibrated the general BCG model to streams in the Northern Piedmont of Maryland. The panel was challenged to 1) assign Biological Condition Gradient attributes to vertebrate (fish and salamander) and invertebrate species recorded in the dataset and 2) to achieve consensus in assigning stream reaches into BCG levels using the fish/salamander and invertebrate assemblage data. The rules used by the panelists were compiled, tested, and refined, and vetted with the panel through a series of meetings and conference calls. The end products were 4 quantitative BCG models to predict the BCG level of a stream based on the rules developed by the panel (1 for invertebrates and 3 for fish/salamander, based on stream size - small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and large (> 8 mi^2)). The invertebrate panel assessed 46 calibration samples and 14 confirmation samples that were not used in the calibration step. The BCG invertebrate model correctly assessed 95.7% of the calibration samples and 92.9% of the confirmation samples. The BCG fish/salamander panel assigned 52 samples to BCG levels during the calibration exercise and assessed 13 more during the confirmation round. The BCG fish/salamander models correctly assessed 100% of the calibration samples and 92.3% of the confirmation samples. The Northern Piedmont BCG models can potentially be used to supplement traditional community data analysis used for water quality assessments.

ACKNOWLEDGEMENTS

The participants in this effort invested significant time and commitment in the process. We are grateful for their hard work and enthusiasm.

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	Andrew Becker
	Charlie Gougeon
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	Christopher Swan
University of Maryland (UMD)	Alan Leslie
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	Bill Shanabruch
	Jeanne Classen
Department of Natural Resources and Environmental Control (DNREC)	Ellen Dickey
Interstate Commission on the Potomac River Basin (ICPRB)	Adam Griggs
	Jim Cummins
US EPA	Laurie Alexander Susan Jackson
Pennsylvania Department of Environmental Protection (PA DEP)	Alan Everett
Versar Inc.	Mark Southerland

ACRONYMS

BCG	Biological Condition Gradient
CWA	Clean Water Act
IBI	Index of Biological Integrity
MBSS	Maryland Biological Stream Survey
MDDNR	Maryland Department of Natural Resources
MO DEP	Montgomery County Department of Environmental Protection
TALU	Tiered Aquatic Life Use
TMC	Ten Mile Creek Watershed
US EPA	U. S. Environmental Protection Agency

TABLE OF CONTENTS

Contents

EXECUTIVE SUMMARY i

1.1 Why Is Measuring Biological Condition Important? 1

1.2 The Biological Condition Gradient 2

2 METHODS AND DATA 8

2.1 Calibrating of the Conceptual BCG Model to Local Conditions 8

2.1.1 Assign Sites to Levels 8

2.1.2 Quantitative Description 9

2.1.3 Decision Criteria Models 10

2.2 Biological Data 12

2.3 Classification 13

2.4 BCG Calibration Exercise 14

3 DECISION RULES AND BCG MODEL FOR MACROINVERTEBRATES 17

3.1 Site Assignments and BCG Level Descriptions 17

3.2 BCG Attribute Metrics 18

3.3 BCG Rule Development 20

3.4 Model Performance 21

4 DECISION RULES AND BCG MODELS FOR FISH & SALAMANDERS 23

4.1 Site Assignments and BCG Level Descriptions 23

4.2 BCG Attribute Metrics 24

4.3 BCG Rule Development 26

4.4 Model Performance 28

5 DESCRIPTION OF ASSEMBLAGES IN EACH BCG LEVEL 28

6 DISCUSSION 32

7 LITERATURE CITED 34

Appendixes

A	**Selected Case Examples from "A Primer on Using Biological Assessments to Support Water Quality Management, EPA 810-R-11-01"**
B	**Narrative BCG Model for the Northern Piedmont, Maryland**
C	**BCG Attribute Assignments – Macroinvertebrates**
D	**BCG Attribute Assignments –Fish and Salamanders**
E	**Macroinvertebrate Capture Probability Modeled vs. Disturbance Gradient**
F	**Fish Capture Probability Modeled vs. Disturbance Gradient**
G	**Sample Worksheets for Fish and Macroinvertebrates**
H	**BCG Level Assignments – Macroinvertebrates**
I	**Box Plots of All Metrics – Macroinvertebrates**
J	**BCG Level Assignments – Fish**
K	**Box Plots of All Metrics – Fish**

Attachments (electronic only)

1.	**Instructions for MS-Excel workbooks of BCG models**
2.	**Microsoft Excel tool for calculating BCG level for macroinvertebrate samples, "Excel_BCGModelNPied_Benthos_20140529.xlsm"**
3.	**Microsoft Excel tool for calculating BCG level for fish/salamander samples, "Excel_BCGModelNPied_Fish_20140529.xlsm"**

LIST OF TABLES

Table 2. Descriptions of the BCG attributes assigned to taxa for this exercise, plus a summary of how many taxa were assigned to each attribute group. 15
Table 3. Examples of Northern Piedmont fish and salamanders by attribute group. 16
Table 4. Examples of Northern Piedmont benthic macroinvertebrates by attribute group. 16
Table 5. Number of calibration and confirmation macroinvertebrate samples that were assessed, organized by BCG level (group consensus). 18
Table 6. BCG quantitative decision rules for macroinvertebrate assemblages. The numbers in parentheses represent the lower and upper bounds of the fuzzy sets (for more details, see Section 2.1.3). 20
Table 7. Model performance for macroinvertebrate calibration and confirmation samples. 23
Table 8. Number of calibration and confirmation fish samples that were assessed, organized by BCG level (group consensus). Models were calibrated for 3 drainage area-based stream size classes: small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and larger (> 8 mi^2). 23
Table 9. BCG quantitative decision rules for fish assemblages in small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and larger streams (> 8 mi^2). The numbers in parentheses represent the lower and upper bounds of the fuzzy sets (for more details, see Section 2.1.3). The mid-water cyprinid taxa metric is comprised of notropis, luxilus, clinostomus and cyprinella, minus swallowtail shiners. 27
Table 10. Model performance for fish/salamander calibration and confirmation samples. 28
Table 11. Description of fish, salamander and macroinvertebrate assemblages in each assessed BCG level. Definitions are modified after Davies and Jackson (2006). 29

LIST OF FIGURES

Figure 1. Biological assessments provide information on the cumulative effects on aquatic communities from multiple stressors. Figure courtesy of David Allen, University of Michigan. 2
Figure 2. The Biological Condition gradient (BCG), modified from Davies and Jackson 2006 3
Figure 3. Steps in a BCG calibration. 8
Figure 4. Flow chart depicting how rules work as a logical cascade in the BCG model. 12
Figure 5. Locations of assessed macroinvertebrate samples, coded by panelist BCG level assignment. 17
Figure 6. Box plots of sensitive (Attribute 2+3) and tolerant (Attribute 5) percent taxa and percent individual metrics for macroinvertebrate calibration samples, grouped by nominal BCG level (group majority choice). Sample sizes for each BCG level are summarized in Table 5. 19
Figure 7. Locations of assessed fish samples, coded by panelist BCG level assignment. 24
Figure 8. Box plots of sensitive (Attribute 2+3) and tolerant (Attribute 5 and 6t) percent taxa and percent individual metrics for fish calibration samples, grouped by nominal BCG level (group majority choice). Sample sizes for each BCG level are summarized in Table 8. 25
Figure 9. Relationship between total taxa metric values and watershed area, fit with a Lowess trend line. Samples are coded by nominal BCG level (group majority choice). 25
Figure 10. Important aquatic species in Maryland's Piedmont headwater streams. 32

1 INTRODUCTION

This document describes the calibration of assessment models in the framework of the Biological Condition Gradient (BCG) for streams in the Northern Piedmont of Maryland. Models were developed for macroinvertebrate and fish/salamander assemblages. The models incorporate multiple attribute decision criteria to assign streams to levels of the BCG. The models were developed using data from the Montgomery County Department of Environmental Protection (MO DEP) and the Maryland Department of Natural Resources (MDDNR) Biological Stream Survey program (MBSS). Participants included scientists from MO DEP, the State of Maryland, the University of Maryland, University of Maryland at Baltimore County, the Interstate Commission Potomac River Basin, US EPA and the states of Virginia, Pennsylvania and Delaware. The Northern Piedmont BCG models can potentially be used to supplement the Index of Biological Integrity (IBI) measures that Montgomery County and Maryland DNR currently use to assess stream health.

1.1 Why Is Measuring Biological Condition Important?

People care about the biota that live in their waters. A natural aquatic community and a surrounding, intact watershed provide many social and economic benefits such as food, recreation and flood control. The US Clean Water Act reflects this public priority by establishing the national goal to restore and maintain the chemical, physical and biological integrity of the Nation's waters.

Biological assessments can be used to directly measure the overall biological integrity of an aquatic community and the synergistic effects of stressors on the aquatic biota residing in a waterbody (Figure 1). Biological assessments are an evaluation of the biological condition of a waterbody using surveys of the structure and function of resident biota. The biota functions as continual monitor of environmental quality, increasing the sensitivity of our assessments by providing a continuous measure of exposure to stressors and access to responses from species that cannot be reared in the laboratory. This increases the likelihood of detecting the effects of episodic events (e.g., spills, dumping, treatment plant malfunctions), toxic nonpoint source pollution (e.g., agricultural pesticides), cumulative pollution (e.g., multiple impacts over time or continuous low-level stress), nontoxic mechanisms of impact (e.g., trophic structure changes due to nutrient enrichment), or other impacts that periodic chemical sampling might not detect. Biotic response to impacts on the physical habitat such as sedimentation from stormwater runoff and physical habitat alterations from dredging, filling, and channelization can also be detected using biological assessments.

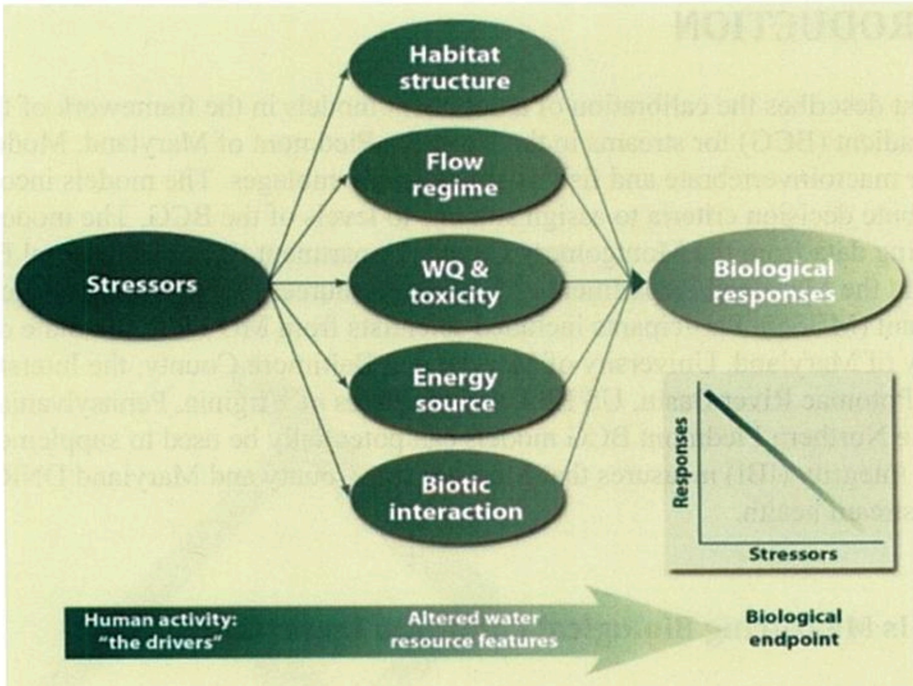

Figure 1. Biological assessments provide information on the cumulative effects on aquatic communities from multiple stressors. Figure courtesy of David Allen, University of Michigan.

1.2 The Biological Condition Gradient

The Biological Condition Gradient (BCG) is a conceptual, narrative model that describes how biological attributes of aquatic ecosystems change along a gradient of increasing anthropogenic stress. It provides a framework for understanding current conditions relative to natural, undisturbed conditions. Some states, such as Maine and Ohio, have used a BCG framework to more precisely define their designated aquatic life uses, monitor status and trends, and track progress in restoration and protection (USEPA 810-R-11). These two states and many others have used biological assessments and BCG-like models to support water quality management over several decades. Based on these efforts, USEPA worked with biologists from across the United States to develop the BCG conceptual model (Davies and Jackson 2006.) The BCG shows an ecologically-based relationship between the stressors affecting a waterbody (the physical, chemical, biological impacts) and the response of the aquatic community, manifested as the biological condition. The model can be adapted or calibrated to reflect specific geographic regions and waterbody type (e.g., streams, rivers, wetlands, estuaries, lakes). Approaches to calibrate the BCG to region-, state-, or tribe-specific conditions have been applied in several ecological regions by multiple states and tribes.

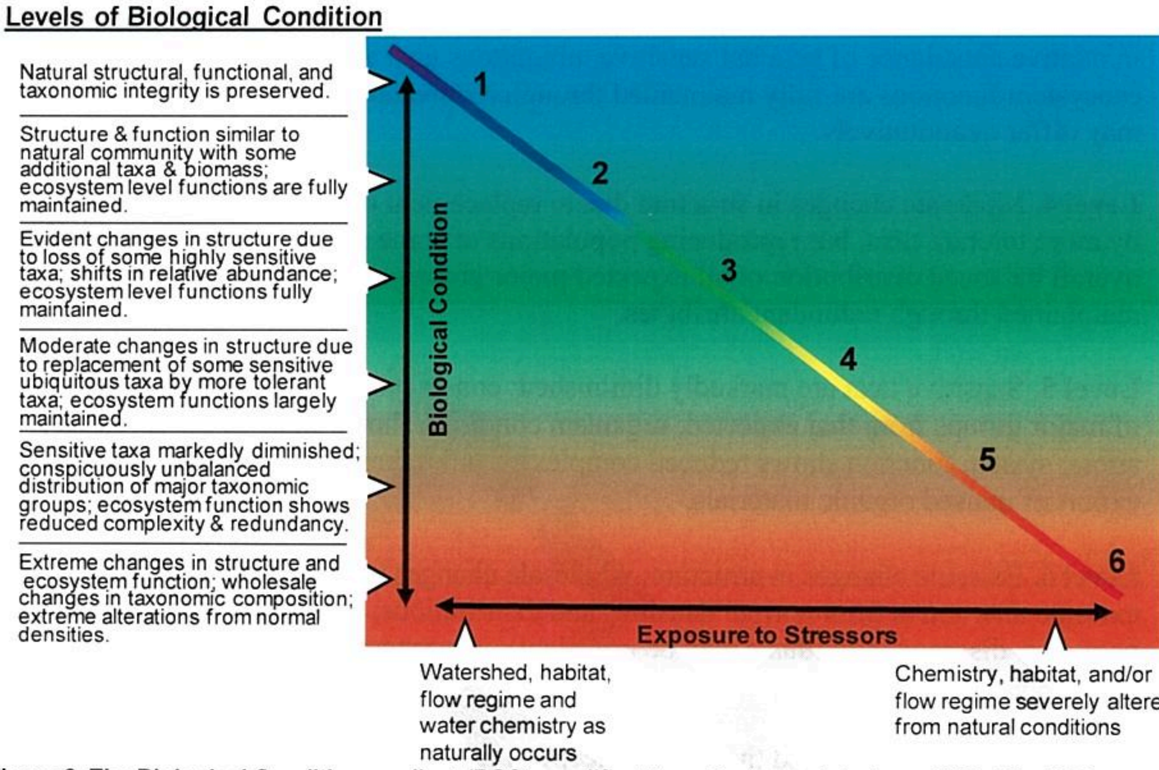

Figure 2. The Biological Condition gradient (BCG), modified from Davies and Jackson 2006. The BCG was developed to serve as a scientific framework to synthesize expert knowledge with empirical observations and develop testable hypotheses on the response of aquatic biota to increasing levels of stress. It is intended to help support more consistent interpretations of the response of aquatic biota to stressors and to clearly communicate this information to the public, and it is being evaluated and piloted in several regions and states.

In practice, the BCG is used to first identify the critical attributes of an aquatic community and then describe how each attribute changes in response to stress. Practitioners can use the BCG to interpret biological condition along a standardized gradient regardless of assessment method and apply that information to different state or tribal programs. For example, Pennsylvania is using a BCG calibrated to its streams to identify exceptional and high-quality waters based on biological condition (exceptional waters may also be identified with other criteria, say, scenic or recreational value) (USEPA 810-R-11).

The BCG is divided into six levels of biological condition along the stressor-response curve, ranging from observable biological conditions found at no or low levels of stress (level 1) to those found at high levels of stress (level 6) (Figure 1-2):

> **Level 1.** Native structural, functional, and taxonomic integrity is preserved; ecosystem function is preserved within range of natural variability. Level 1 describes waterbodies that are pristine, or biologically indistinguishable from pristine condition.
>
> **Level 2.** Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Level 3. Some changes in structure due to loss of some highly sensitive native taxa; shifts in relative abundance of taxa but sensitive–ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system, but may differ quantitatively.

Level 4. Moderate changes in structure due to replacement of sensitive–ubiquitous taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes.

Level 5. Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased buildup or export of unused organic materials.

Level 6. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor (e.g. diseased individuals may be prevalent); ecosystem functions are severely altered.

The scientific panels that developed the BCG conceptual model identified 10 attributes of aquatic ecosystems that change in response to increasing levels of stressors along the gradient, from level 1 to 6 (see Table 1). The attributes include several aspects of community structure, organism condition, ecosystem function, spatial and temporal attributes of stream size, and connectivity.

Each attribute provides some information about the biological condition of a waterbody. Combined into a model like the BCG, the attributes can offer a more complete picture about current waterbody conditions and also provide a basis for comparison with naturally expected waterbody conditions. All states and tribes that have applied a BCG used the first seven attributes that describe the composition and structure of biotic community on the basis of the tolerance of species to stressors and, where available, included information on the presence or absence of native and nonnative species and, for fish and amphibians, observations on overall condition (e.g., size, weight, abnormalities, tumors).

Table 1. Biological and other ecological attributes used to characterize the BCG.

Attribute	Description
I. Historically documented, sensitive, long-lived, or regionally endemic taxa	Taxa known to have been supported according to historical, museum, or archeological records, or taxa with restricted distribution (occurring only in a locale as opposed to a region), often due to unique life history requirements (e.g., sturgeon, American eel, pupfish, unionid mussel species).
II. Highly sensitive (typically uncommon) taxa	Taxa that are highly sensitive to pollution or anthropogenic disturbance. Tend to occur in low numbers, and many taxa are specialists for habitats and food type. These are the first to disappear with disturbance or pollution (e.g., most stoneflies, brook trout [in the east], brook lamprey).
III. Intermediate sensitive and common taxa	Common taxa that are ubiquitous and abundant in relatively undisturbed conditions but are sensitive to anthropogenic disturbance/pollution. They have a broader range of tolerance than Attribute II taxa and can be found at reduced density and richness in moderately disturbed sites (e.g., many mayflies, many darter fish species).
IV. Taxa of intermediate tolerance	Ubiquitous and common taxa that can be found under almost any conditions, from undisturbed to highly stressed sites. They are broadly tolerant but often decline under extreme conditions (e.g., filter-feeding caddisflies, many midges, many minnow species).
V. Highly tolerant taxa	Taxa that typically are uncommon and of low abundance in undisturbed conditions but that increase in abundance in disturbed sites. Opportunistic species able to exploit resources in disturbed sites. These are the last survivors (e.g., tubificid worms, black bullhead).
VI. Nonnative or intentionally introduced species	Any species not native to the ecosystem (e.g., Asiatic clam, zebra mussel, carp, European brown trout). Additionally, there are many fish native to one part of North America that have been introduced elsewhere.
VII. Organism condition	Anomalies of the organisms; indicators of individual health (e.g., deformities, lesions, tumors).
VIII. Ecosystem function	Processes performed by ecosystems, including primary and secondary production; respiration; nutrient cycling; decomposition; their proportion/dominance; and what components of the system carry the dominant functions. For example, shift of lakes and estuaries to phytoplankton production and microbial decomposition under disturbance and eutrophication.
IX. Spatial and temporal extent of detrimental effects	The spatial and temporal extent of cumulative adverse effects of stressors; for example, groundwater pumping in Kansas resulting in change in fish composition from fluvial dependent to sunfish.
X. Ecosystem connectance	Access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life; the opposite of fragmentation. For example, levees restrict connections between flowing water and floodplain nutrient sinks (disrupt function); dams impede fish migration, spawning. Extensive burial of headwater streams leads to cumulative downstream impacts to biota through energy input disruption, habitat modification, and loss of refugia and dispersing colonists.

Source: Modified from Davies and Jackson 2006.

The last three BCG attributes of ecosystem function, connectance, and spatial and temporal extent of detrimental effects can provide valuable information when evaluating the potential for a waterbody to be protected or restored. For example, a manager can choose to target resources and restoration activities to a stream where there is limited spatial extent of stressors or there are adjacent intact wetlands and stream buffers or intact hydrology versus a stream with comparable biological condition but where adjacent wetlands have been recently eliminated, hydrology is being altered, and stressor input is predicted to increase.

The BCG model provides a framework to help water quality managers do the following:

Decide what environmental conditions are desired (goal-setting)—The BCG can provide a framework for organizing data and information and for setting achievable goals for waterbodies relative to "natural" conditions, e.g., condition comparable or close to undisturbed or minimally disturbed condition.

Interpret the environmental conditions that exist (monitoring and assessment)—managers can get a more accurate picture of current waterbody conditions.

Plan for how to achieve the desired conditions and measure effectiveness of restoration—The BCG framework offers water program managers a way to help evaluate the effects of stressors on a waterbody, select management measures by which to alleviate those stresses, and measure the effectiveness of management actions.

Communicate with stakeholders—When biological and stress information is presented in this framework, it is easier for the public to understand the status of the aquatic resources relative to what high-quality places exist and what might have been lost.

Specifically, biological assessment information has been used by federal, state, tribal and local governments to:

- **Define goals for a waterbody**—Information on the composition of a naturally occurring aquatic community can provide a description of the expected biological condition for other similar waterbodies and a benchmark against which to measure the biological integrity of surface waters. Many states and tribes have used such information to more precisely define their designated aquatic life uses, develop biological criteria, and measure the effectiveness of controls and management actions to achieve those uses.

- **Report status and trends**—Depending on level of effort and detail, biological assessments can provide information on the status of the condition of the expected aquatic biota in a waterbody and, over time with continued monitoring, provide information on long-term trends.

- **Identify high-quality waters and watersheds**—Biological assessments can be used to identify high-quality waters and watersheds and support implementation of antidegradation policies.

- **Document biological response to stressors**—Biological assessments can provide information to help develop biological response signatures (e.g., a measurable, repeatable response of specific species to a stressor or category of stressors). Examples include sensitivity of mayfly species (pollution-sensitive aquatic insects) to metal toxicity or temperature-specific preferences of fish species. Such information can provide an additional line of evidence to support stressor identification and causal analysis (USEPA 2000a), as well as to inform numeric criteria development (USEPA 2010a).

1.3 Calibrating the Conceptual BCG Model to Local Conditions

The BCG can serve as a starting point for defining the response of aquatic biota to increasing levels of stress in a specific region. The model can be applied to any region or waterbody by calibrating it to local conditions using specific expertise and local data. To date, most states and tribes are calibrating the BCG using the first seven attributes that characterize the biotic community primarily on the basis of tolerance to stressors, presence/absence of native and nonnative species, and organism condition.

A multistep process is followed to calibrate a BCG to local conditions (Figure 3); to describe the native aquatic assemblages under natural conditions; to identify the predominant regional stressors; and to describe the BCG, including the theoretical foundation and observed assemblage response to stressors. Calibration begins with the assembly and analysis of biological monitoring data. Next, a calibration workshop is held in which experts familiar with local conditions use the data to define the ecological attributes and set narrative statements; for example, narrative decision rules for assigning sites to a BCG level on the basis of the biological information collected at sites. Documentation of expert opinion in assigning sites to tiers is a critical part of the process. A decision model can then be developed that encompasses those rules and is tested with independent data sets. A decision model based on the tested decision rules is a transparent, formal, and testable method for documenting and validating expert knowledge. A quantitative data analysis program can then be developed using those rules.

Each attribute provides some information about the biological condition of a waterbody. Combined into the BCG model, the attributes can offer a more complete picture about current waterbody conditions and also provide a basis for comparison with naturally expected conditions. All states and tribes that have applied a BCG used the first seven attributes that describe the composition and structure of biotic community on the basis of the tolerance of species to stressors and, where available, included information on the presence or absence of native and nonnative species and, for fish and amphibians, observations on overall condition (e.g., size, weight, abnormalities, tumors).

The last three BCG attributes of ecosystem function, connectance, and spatial and temporal extent of detrimental effects can provide valuable information when evaluating the potential for a waterbody to be protected or restored. For example, a manager can choose to target resources and restoration activities to a stream where there is limited spatial extent of stressors or there are adjacent intact wetlands and stream buffers or intact hydrology versus a stream with comparable biological condition but where adjacent wetlands have been recently eliminated, hydrology is being altered, and stressor input is predicted to increase.

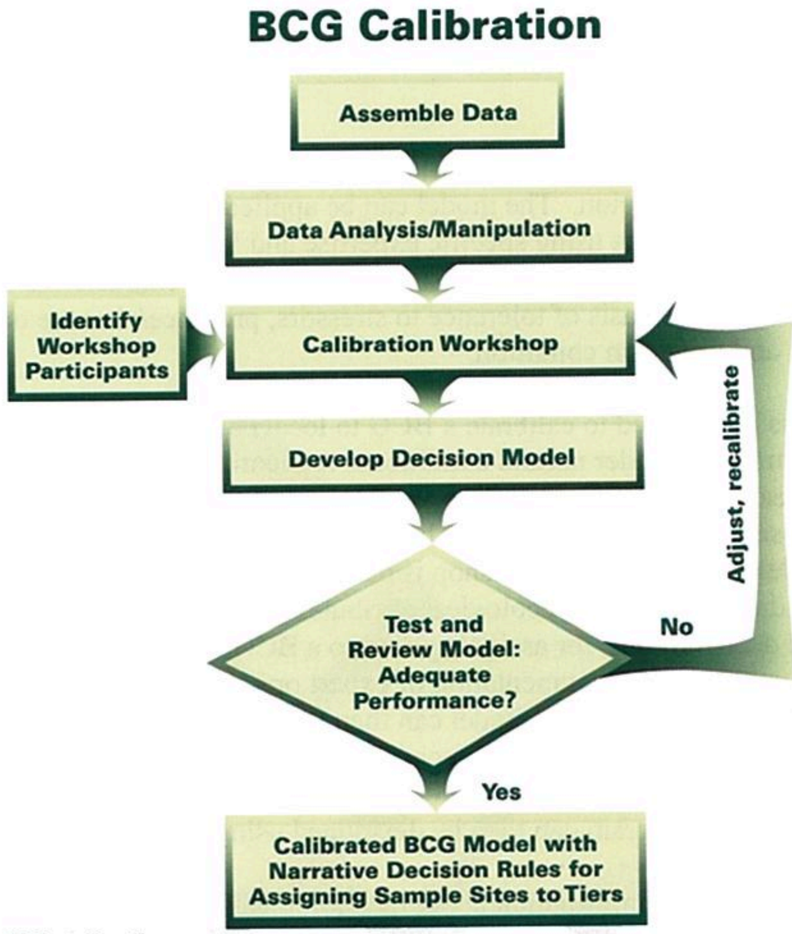

Figure 3. Steps in a BCG calibration.

2 METHODS AND DATA

2.1 Calibrating of the Conceptual BCG Model to Local Conditions

2.1.1 *Assign Sites to Levels*

The conceptual model of the BCG is intended to be universal (US EPA 2005, Davies and Jackson 2006), but descriptions of communities, species, and their responses to the stressor gradient are specific to the conditions and communities found in the sample region. Before assigning sites to BCG levels, the expert panel begins by describing the biological condition levels that can be discerned within their region. The description of natural conditions requires biological knowledge of the region, a natural classification of the assemblages, and, if available, historical descriptions of the habitats and assemblages.

The panelists examine species composition and abundance data from sites with different levels of cumulative stress, ranging from least stressed to severely stressed. The panel works with data tables showing the species and attributes for each sample. In developing assessments, the panel works "blind", that is, no stressor information is included in the data table. Only non-anthropogenic classification variables are shown. Panel members discuss the species composition and what they expect to see for each level of the BCG (e.g., "I expect to see more stonefly taxa in a BCG Level 2 site"), and then assign samples to BCG levels. These site assignments are used to describe changes in the aquatic communities for a range of anthropogenic stress, leading to a complete descriptive model of the BCG for the region.

2.1.2 Quantitative Description

BCG level descriptions in the conceptual model tend to be rather general (e.g., "reduced richness"). To allow for consistent assignments of sites to levels, it is necessary to formalize the expert knowledge by codifying level descriptions into a set of rules (e.g., Droesen 1996). If formalized properly, any person (with data) can follow the rules to obtain the same level assignments as the group of experts. This makes the actual decision criteria transparent to stakeholders.

Rules are logic statements that experts use to make their decisions; for example, "If taxon richness is high, then biological condition is high." Rules on attributes can be combined, for example: "If the number of highly sensitive taxa (Attribute II) is high, <u>and</u> the number of tolerant individuals (Attribute V) is low, then assignment is Level 2." In questioning individuals on how decisions are made in assigning sites to levels, people generally do not use inflexible, "crisp" rules, for example, the following rule is unlikely to be adopted:

"Level 2 always has 10 or more Attribute II taxa; 9 Attribute II taxa is always Level 3."

Rather, people use strength of evidence in allowing some deviation from their ideal for any individual attributes, as long as most attributes are in or near the desired range. Clearly, the definitions of "high," "moderate," "low," etc., are fuzzy. These rules preserve the collective professional judgment of the expert group and set the stage for the development of models that reliably assign sites to levels without having to reconvene the same group. In essence, the rules and the models capture the panel's collective decision criteria.

As the panel assigns example sites to BCG levels, the members are polled on the critical information and criteria they use to make their decisions. These form preliminary, narrative rules that explain how panel members make decisions. For example, "For BCG Level 2, sensitive taxa must make up half or more of all taxa in a sample." The decision rule for a single level of the BCG does not always rest on a single attribute (e.g., highly sensitive taxa) but may include other attributes as well (intermediate sensitive taxa, tolerant taxa, indicator species), so these are termed "Multiple Attribute Decision Rules." With data from the sites, the rules can be checked and quantified. Quantification of rules allows users to consistently assess sites according to the same rules used by the expert panel, and allows a computer algorithm, or other persons, to obtain the same level assignments as the panel.

Rule development requires discussion and documentation of BCG level assignment decisions and the reasoning behind the decisions. During this discussion, we record:

- Each participant's decision ("vote") for the site
- The critical or most important information for the decision—for example, the number of taxa of a certain attribute, the abundance of an attribute, the presence of indicator taxa, etc.
- Any confounding or conflicting information and how this was resolved for the eventual decision

Following the initial site assignment and rule development, we develop descriptive statistics of the attributes and other biological indicators for each BCG level determined by the panel. These descriptions assist in review of the rules and their iteration for testing and refinement.

Rule development is iterative, and may require 2 or more panel sessions. Following the initial development phase, the draft rules are tested by the panel with new data to ensure that new sites are assessed in the same way. The new test sites are not used in the initial rule development and also should span the range of anthropogenic stress. Any remaining ambiguities and inconsistencies from the first iterations are also resolved.

2.1.3 Decision Criteria Models

Consensus professional judgment used to describe the BCG levels can take into account nonlinear responses, uncommon stressors, masking of responses, and unequal weighting of attributes. This is in contrast to the commonly-used biological indexes, which are typically unweighted sums of attributes (e.g., multimetric indexes; Barbour et al. 1999, Karr and Chu 1999), or a single attribute, such as observed to expected taxa (e.g., Simpson and Norris 2000, Wright 2000). Consensus assessments built from the professional judgment of many experts result in a high degree of confidence in the assessments, but the assessments are labor-intensive (several experts must rate each site). It is also not practical to reconvene the same group of experts for every site that is monitored in the long term. Since experts may be replaced on a panel over time, assessments may in turn "drift" due to individual differences of new panelists. Management and regulation, however, require clear and consistent methods and rules for assessment, which do not change unless deliberately reset.

Use of the BCG in routine monitoring and assessment thus requires a way to automate the consensus expert judgment so that the assessments are consistent. The expert rules are automated in Multiple Attribute Decision Models. These models replicate the decision criteria of the expert panel by assembling the decision rules using logic and set theory, in the same way the experts used the rules. Instead of a statistical prediction of expert judgment, this approach directly and transparently converts the expert consensus to automated sample assessment. The method uses modern mathematical set theory and logic (called "fuzzy set theory") applied to rules developed by the group of experts. Fuzzy set theory is directly applicable to environmental assessment, and has been used extensively in engineering applications worldwide (e.g., Demicco and Klir 2004) and environmental applications have been explored in Europe and Asia (e.g., Castella and Speight 1996, Ibelings et al. 2003).

Mathematical fuzzy set theory allows degrees of membership in sets, and degrees of truth in logic, compared to all-or-nothing in classical set theory and logic. Membership of an object in a set is defined by its membership function, a function that varies between 0 and 1. To illustrate, we compare how classical set theory and fuzzy set theory treat the common classification of sediment, where sand is defined as particles less than or equal to 2.0 mm diameter, and gravel is greater than 2.0 mm (Demicco and Klir 2004). In classical "crisp" set theory, a particle with diameter of 1.999 mm is classified as "sand", and one with 2.001 mm diameter is classified as "gravel." In fuzzy set theory, both particles have nearly equal membership (approximately 0.5) in both classes (Demicco 2004). Very small measurement error in particle diameter greatly increases the uncertainty of classification in classical set theory, but not in fuzzy set theory (Demicco and Klir 2004). Demicco and Klir (2004) proposed four reasons why fuzzy sets and fuzzy logic enhance scientific methodology:

- Fuzzy set theory has greater capability to deal with "irreducible measurement uncertainty," as in the sand/gravel example above.
- Fuzzy set theory captures vagueness of linguistic terms, such as "many," "large" or "few."
- Fuzzy set theory and logic can be used to manage complexity and computational costs of control and decision systems.
- Fuzzy set theory enhances the ability to model human reasoning and decision-making, which is critically important for defining thresholds and decision levels for environmental management.

An example of the quantitative rules and inference is shown in Appendix L.

Once the quantitative rules for each BCG level have been developed, they work as a logical cascade from BCG Level 1 to Level 6. A sample is first tested against the Level 1 rules; if the combined rule fails, then the Level fails, and the assessment moves down to Level 2, and so on (Figure 4). All required rules must be true for a site to be assigned to a level. The output of the inference model may include membership of a sample in a single level only, ties between levels, and varying memberships among two or more levels. The level with the highest membership value is taken as the nominal level.

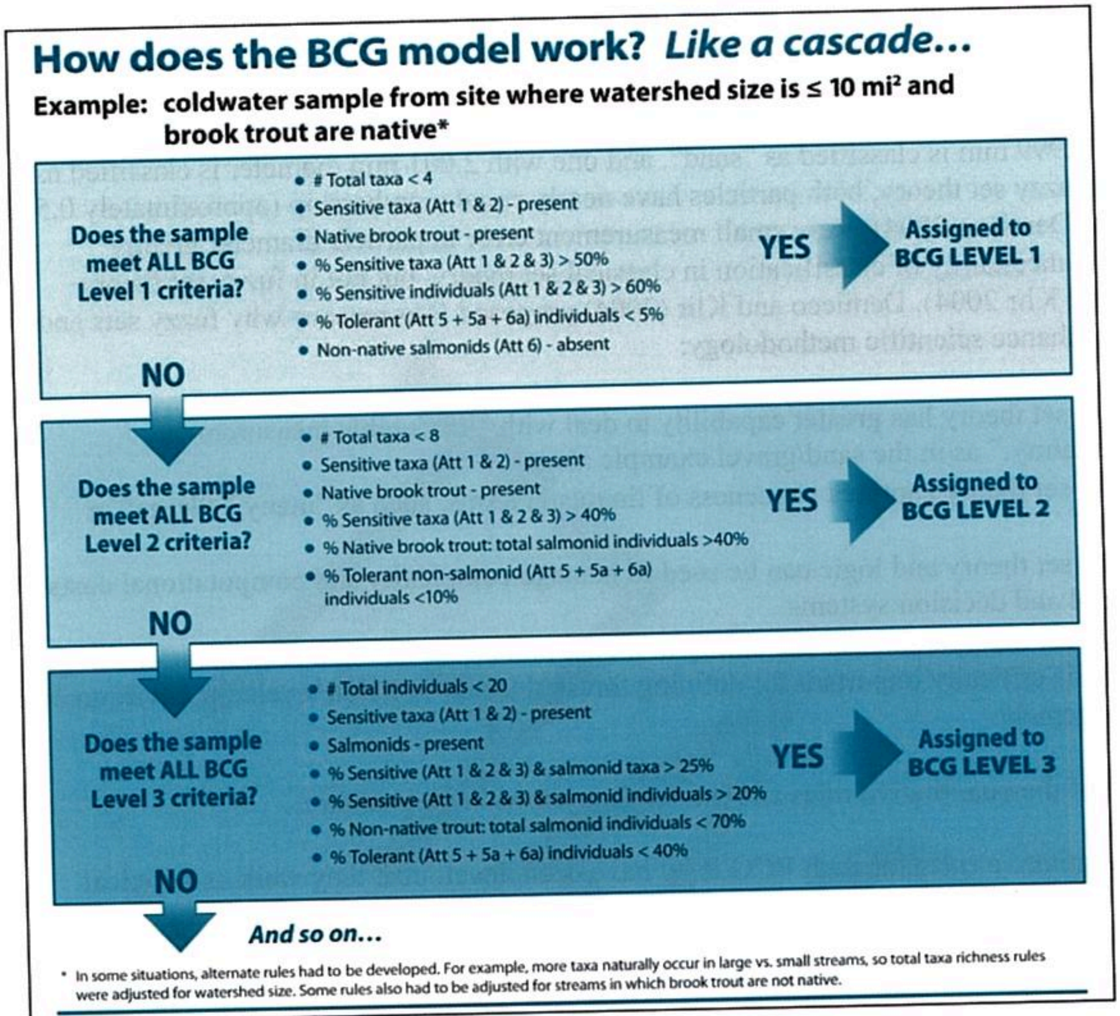

Figure 4. Flow chart depicting how rules work as a logical cascade in the BCG model.

2.2 Biological Data

Biological data for three assemblages (fish, macroinvertebrates and salamanders) were obtained from MO DEP and MDDNR's MBSS program. Sampling sites were located in the Northern Piedmont ecoregion (Woods et al. 1999). The fish dataset consists of 777 samples (62 MO DEP samples and 715 MBSS samples) from 629 unique sites, while the macroinvertebrate dataset has 829 samples (73 MO DEP samples and 756 MBSS samples). Sampling dates for the MBSS data range from 1999-2010, while the MO DEP data were collected from 1997 to 2013.

MO DEP and MBSS use similar biological sampling methods. Fish sampling is conducted with a backpack electrofishing unit. Two electrofishing passes are conducted within a 75-meter reach, with channel block nets placed securely at both ends of the reach. All available habitat types are sampled, and all fish are netted and removed during each pass. Fishes greater than 30 mm in length are identified to species and enumerated. Index periods differ slightly, with MBSS fish sampling taking place from June 1 to September 30, and MO DEP sampling going from June 1 to mid-October (Stranko et al. 2014, MO DEP 2014).

Macroinvertebrate samples are collected from multiple habitats and composited. The habitats are sampled in proportion to their occurrence within the 75-meter reach. All potentially productive habitats are represented in the sample, in the following order of preference: riffles, root wads, root mats/woody debris/snag, leaf packs, submerged aquatic vegetation/associated habitat, undercut banks; less preferred are gravel, broken peat, clay lumps, detrital/sand areas in runs; moving water is preferred over still water. Approximately 20 kicks/jabs/sweeps/rubs are taken from the habitats, with a total sampling area of approximately 20 ft^2. Samples are collected with D-frame nets. Mesh size differs slightly across the two programs (MBSS uses 450 µm and MoCo uses 500-µm). The MBSS index period runs from March 1 to April 30, while MO DEP samples from March 15 to April 30. Both MBSS and MO DEP subsample a minimum of 120 organisms. Identifications are done to genus-level, unless the specimen is damaged or the specimen is an early instar, such that positive identification to genus is not possible (in that case, the specimen is identified to family). Oligochaetes are identified to the family-level and Chironomids to the subfamily or tribe-level. Prior to 2000, Chironomids were identified to the family-level (Stranko et al. 2014, MO DEP no date).

Salamander surveys are conducted along a 25 by 1-meter transect paralleling the stream. Approximately 15 minutes are spent searching the best available habitat within the riparian area of the stream. All available cover objects (including cobbles, small boulders, logs, or other objects) are searched. Only salamanders found on one side of the stream are recorded to ensure comparability across sites. The side that is searched is selected randomly. Numbers by species are recorded (Stranko et al. 2014).

2.3 Classification

Experience has shown that a robust biological classification is necessary to calibrate the BCG, because the natural biological class indicates the species expected to be found in undisturbed, high-quality sites. As an example, low-gradient prairie or wetland-influenced streams typically contain species that are adapted to slow-moving water and often to hypoxic conditions. These same species found in a high-gradient, forested streams could indicate habitat degradation and organic enrichment.

This project focused on one EPA Level 3 ecoregion (Omernik 1987), the Northern Piedmont. The Northern Piedmont covers parts of New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and Virginia, running from southwest to northeast. It is a transitional area, located between topographically flatter coastal areas to the east and more mountainous regions to the west and north. Landforms include low, rounded hills, irregular plains, and open valleys (Woods et al. 1999).

For this project, only sites in the Northern Piedmont region of Maryland were assessed. One BCG model was calibrated for all of the macroinvertebrate samples. Fish and salamander samples were divided into 3 broad groups based on drainage area: small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and large (> 8 mi^2). BCG models were calibrated for each of these 3 size classes. Thresholds were selected based on input from the expert panel. Stream size exerts a major influence on the longitudinal shift in fish assemblages (Vannote et al. 1980, Kanno and Vokoun

2008). Streams with drainage areas less than 0.5 mi^2 were assessed but later excluded from the BCG calibration dataset because there are too few species in streams of this size to calibrate a BCG model.

2.4 BCG Calibration Exercise

Calibration of the BCG for a region is a collective exercise among regional biologists to develop consensus assessments of sites, and then to elicit the rules that the biologists use to assess the sites (Davies and Jackson 2006). On March 27, 2013, Montgomery County convened a panel of 17 scientists with expertise in stream ecology, benthic macroinvertebrate (e.g. insects, crayfish, mussels, snails, worms) and fish and salamander community assessments. The experts attending the meeting included scientists from Montgomery County, the State of Maryland, the University of Maryland, University of Maryland at Baltimore County, the Interstate Commission Potomac River Basin and US EPA. At this all-day meeting, a narrative BCG model was developed for 1st to 3rd order streams with catchment areas ranging from 0.5 to 5 mi^2 in the Northern Piedmont of Montgomery County, Maryland (Appendix B), and a preliminary model for the Ten Mile Creek (TMC) watershed was developed and tested successfully (Jackson et al. 2013).

On September 24 – 26, 2013, Montgomery County convened a second expert meeting with a larger number of sites for analysis and with an expanded group of experts, including scientists from the states of Virginia, Pennsylvania and Delaware. A more robust and in-depth analysis of the sites was necessary to refine the model developed during the March meeting. The goal was to develop a set of decision criteria rules for assigning sites to the BCG levels for streams in the Northern Piedmont of Maryland. As part of this process, panelists first assigned BCG attributes to macroinvertebrate, fish and salamander taxa (Tables 1 & 2, Appendices C and D). Panelists assigned Attribute 6 (non-native) fish taxa to sub-attributes to distinguish sensitive, intermediate and tolerant taxa (Table 2). Table 2 contains a summary of how many macroinvertebrate, fish and salamander taxa were assigned to each attribute group. Examples of Northern Piedmont taxa that were assigned to each attribute group are listed in Tables 3 and 4. Prior to making attribute assignments, panelists reviewed plots showing the capture probabilities of macroinvertebrate and fish taxa versus disturbance gradients to help inform their decisions (Appendices E and F, respectively).

During the September workshop, the panelists examined biological data from individual sites and assigned those samples to levels 1 to 6 of the BCG. The intent was to achieve consensus and to identify rules that experts were using to make their assignments. The data that the experts examined when making BCG level assignments were provided in worksheets. The worksheets contained lists of taxa, taxa abundances, BCG attribute levels assigned to the taxa, BCG attribute metrics and limited site information, such as watershed area, size class (i.e. headwater), and percent forest. Participants were not allowed to view Station IDs or waterbody names when making BCG level assignments, as this might bias their assignments. Sample fish and macroinvertebrate worksheets can be found in Appendix G.

A preliminary set of decision rules were developed based on these calibration worksheets. The rules were automated in an Excel spreadsheet and BCG level assignments were calculated for each sample. The model-assigned BCG level assignments were then compared to the BCG level assignments that had been made by the panelists to evaluate model performance. On November 7, 2013, a follow-up webinar was held to discuss samples that had the greatest differences between the BCG level assignments based on the model versus the panelists. Decision rules were adjusted based on group consensus. Then the panelists worked individually to make BCG level assignments on additional samples to confirm the BCG models. A final webinar was held on April 29, 2014 to discuss the performance of the models on the calibration and confirmation datasets, to reach consensus on samples where the BCG model output did not match exactly with the group consensus, and to finalize the rules.

Table 1. Descriptions of the BCG attributes assigned to taxa for this exercise, plus a summary of how many taxa were assigned to each attribute group.

BCG Attribute	Description	Fish taxa		Invertebrate taxa		Salamander taxa
		Assessed	In dataset	Assessed	In dataset	
1	Historically documented, sensitive, long-lived or regionally endemic taxa	5	1	0	0	0
2	Highly sensitive taxa, often occur in low abundance	7	6	58	35	2
3	Intermediate sensitive taxa	10	10	90	68	0
4	Taxa of intermediate tolerance	13	13	178	105	1
5	Tolerant native taxa	11	11	93	36	0
6	Non-native taxa	--	--	5	1	0
6i	Sensitive non-native (e.g., highly-valued recreational taxa like salmonids)	2	2	--	--	--
6m	Non-native taxa of intermediate tolerance	6	5	--	--	--
6t	Highly tolerant non-native taxa	7	7	--	--	--
10	Catadromous fish, indicating ecosystem connectivity	3	3	0	--	--
x	No attribute assignment (insufficient information)	15	15	198	46	9
Totals		***79***	***73***	***622***	***291***	***12***

Table 2. Examples of Northern Piedmont fish and salamanders by attribute group.

Ecological Attribute	Number of species	Example Species
I Endemic, rare	5	Brook trout, bridle shiner, Chesapeake log perch, Maryland darter, trout perch
II Highly Sensitive	7	Yellow perch, northern hog sucker, margined mad tom, dusky salamander, longtailed salamander
III Intermediate Sensitive	11	Fallfish, fantail darter, Potomac sculpin, Blue Ridge sculpin
IV Intermediate Tolerant	14	Channel catfish, least brook lamprey, pumpkinseed, tessellated darter
V Tolerant	13	American eel, mummichog, white sucker, sea lamprey, northern two-lined salamander
VI-i Sensitive Nonnative	2	brown trout, rainbow trout
VI-m Intermediate nonnative	6	Black crappie, golden redhorse, smallmouth bass
VI-t Tolerant nonnative	6	common carp, goldfish, green sunfish, largemouth bass, snakehead
x Unassigned		Unidentified fish, hybrids

Table 3. Examples of Northern Piedmont benthic macroinvertebrates by attribute group.

Ecological Attribute	Number of taxa	Example Species
I Endemic, rare		None attributed
II Highly Sensitive	~50	Mayflies: *Habrophlebia, Epeorus, Ephemera, Leucrocuta, Habrophlebiodes, Paraleptophlebia,* Stoneflies: *Sweltsa, Talloperla, Eccoptura,* Caddisflies: *Wormaldia, Diplectrona, Rhyacophila, Dolophilodes,* Flies: *Dixa,* Prodiamesinae
III Intermediate Sensitive	~60	Mayflies: *Diphetor, Ephemerella, Ameletus, Serratella,* Stoneflies: *Amphinemura, Acroneuria, Leuctra, Isoperla,* Dragonflies: *Cordulegaster, Lanthus,* Caddisflies: *Neophylax, Rhyacophila, Pycnopsyche, Glossosoma,* Beetles: *Oulimnius, Anchytarsus,* Flies: Diamesinae, *Hexatoma, Prosimulium*
IV Intermediate Tolerant	>100	Mayflies: *Baetis, Stenonema,* Damsel and Dragonflies: *Calopteryx, Boyeria,* Caddisflies: *Hydropsyche, Polycentropus,* Beetles: *Helichus, Optioservus,* Fishflies: *Nigronia,* Other: *Chelifera,* Tanytarsini, *Tipula, Tabanidae, Crangonyx,* Enchytraeidae
V Tolerant	>50	Beetles: Hydrophilidae, Dytiscidae, Flies: *Hemerodromia,* most Chironomini and Orthocladiinae, Stratiomyiidae, Other: Isopoda, Physidae, Hirudinae, Tubificidae
V Nonnative	2	Asian Clam: *Corbicula,* Snails: *Bithnya*
x Unassigned		Ambiguous family-level or order-level identifications, unknown tolerance

3 DECISION RULES AND BCG MODEL FOR MACROINVERTEBRATES

The macroinvertebrate BCG model was calibrated using MO DEP and MBSS samples. During the calibration exercise, panelists made BCG level assignments on 46 samples. In order to confirm the model, panelists made BCG level assignments on 14 additional samples. BCG level assignments for these 60 samples are summarized in Appendix H.

3.1 Site Assignments and BCG Level Descriptions

The group assigned macroinvertebrate samples to 5 BCG levels (BCG levels 2-6) (Table 5). Locations of the assessed sites are shown in Figure 5. There was never a majority opinion for sites at BCG Level 1, which is the most pristine condition (Davies and Jackson 2006). Participants agreed that all sites within the Northern Piedmont have some degree of disturbance, including legacy effects from agriculture and forestry from 100 to 200 years ago (Jackson et al. 2013), so BCG level 2 samples represent the highest quality waters in this exercise. Of the 60 samples that were assessed, 7 were assigned to BCG level 2 and 4 were assigned to BCG level 6, which represents the most highly stressed condition. The majority of samples were assigned to BCG levels 3 and 4 (Table 5).

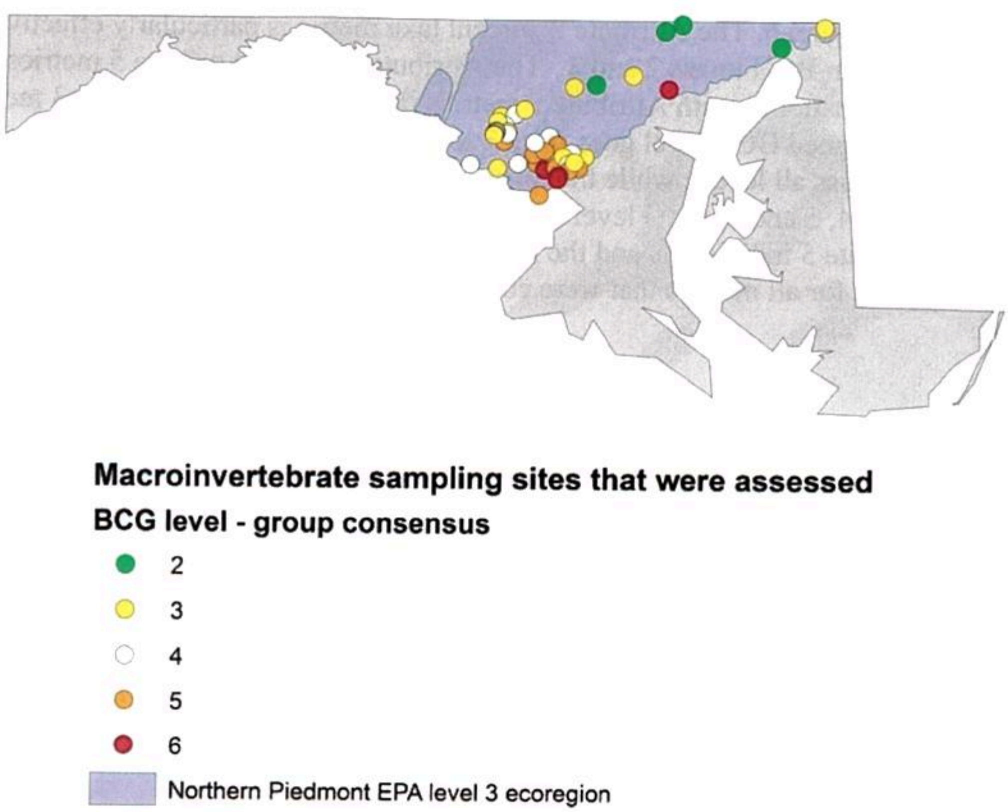

Figure 5. Locations of assessed macroinvertebrate samples, coded by panelist BCG level assignment.

Table 4. Number of calibration and confirmation macroinvertebrate samples that were assessed, organized by BCG level (group consensus).

BCG level	Calibration	Confirmation
1	0	0
2	4	3
3	14	6
4	14	3
5	10	2
6	4	0
Totals	***46***	***14***

3.2 BCG Attribute Metrics

Examinations of taxonomic attributes among the BCG levels determined by the panel showed that several of the attributes are useful in distinguishing levels, and indeed, were used by the panel's biologists for decision criteria. The most important considerations were number of total taxa and percent individual and percent taxa metrics for sensitive (Attribute 2, 3) and tolerant (Attribute 5) organisms. Box plots showing the distributions of these metrics across the 5 BCG levels are shown in Figure 6. The Attribute 2 percent taxa metric is particularly effective at discriminating between BCG levels 2 and 3. The Attribute 2+3 and Attribute 5 metrics show relatively monotonic patterns, with Attribute 5 metrics increasing and Attribute 2+3 metrics decreasing as the assigned BCG level goes from 2 to 6. The Attribute 2+3 taxa metrics discriminate well across all levels, while the tolerant taxa metrics discriminate particularly well between BCG levels 4, 5 and 6. BCG level 5 is discriminated from other BCG levels by the dominance of Attribute 5 individuals and the loss or very limited presence of Attribute 2+3 taxa (Figure 6). Box plots for all metrics that were considered in this exercise can be found in Appendix I.

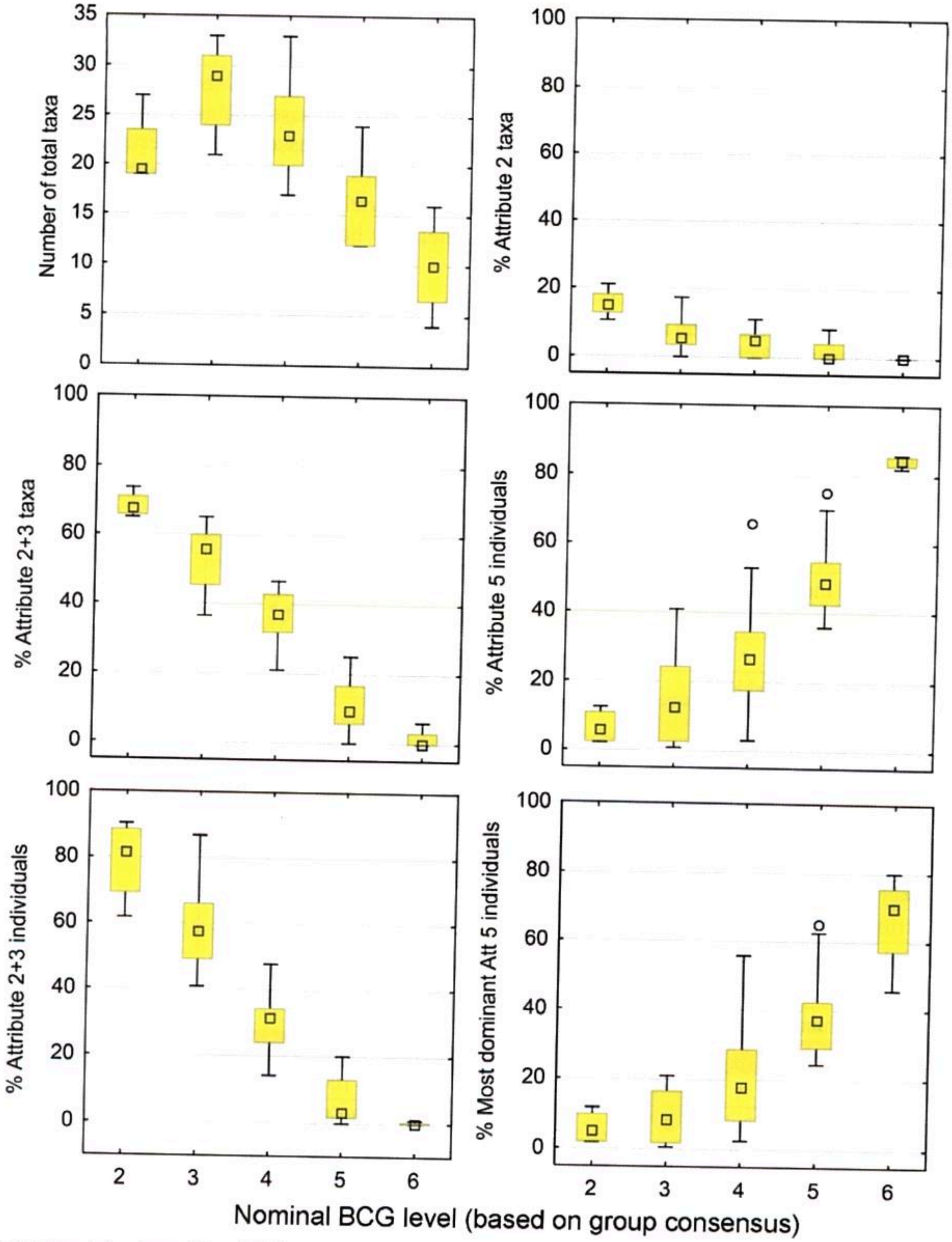

Figure 6. Box plots of sensitive (Attribute 2+3) and tolerant (Attribute 5) percent taxa and percent individual metrics for macroinvertebrate calibration samples, grouped by nominal BCG level (group majority choice). Sample sizes for each BCG level are summarized in Table 5.

3.3 BCG Rule Development

The rules shown in Table 6 have been developed for distinguishing BCG levels for streams in the Northern Piedmont of Maryland based on the macroinvertebrate assemblage. They were derived from discussions with the panelists on why individual sites were assessed at a certain level. The rules were calibrated and confirmed with the 60 macroinvertebrate samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible. Inevitably, there were some decisions where the panel may have used different, unstated rules, or where rules were inconsistently applied.

Table 5. BCG quantitative decision rules for macroinvertebrate assemblages. The numbers in parentheses represent the lower and upper bounds of the fuzzy sets (for more details, see Section 2.1.3).

BCG Level 2	**rule**	
# Total taxa	> 17 (13-22)	
% Attribute 2 taxa	≥ 8% (5-10)	
% Attribute 2+3 taxa	≥ 50% (45-55)	
% Attribute 2 individuals	≥ 3% (2-5)	
% Attribute 2+3 individuals	≥ 60% (55-65)	
% Attribute 5 individuals	≤ 15% (10-20)	
BCG Level 3	**alt 1**	**alt 2**
# Total taxa	> 17 (13-22)	
% Attribute 2+3 individuals	≥ 40% (35-45)	
# Attribute 2 taxa	--	≥ 1 (0-2)
% Attribute 2+3 taxa	≥ 25% (20-30)	≥ 45% (40-50)
% Attribute 5 individuals	≤ 40% (35-45)	≤ 50% (45-55)
% Most dominant Attribute 5 individual	≤ 20% (15-25)	--
BCG Level 4	**rule**	
# Total taxa	≥ 15 (10-20)	
% Attribute 2+3 taxa	≥ 20% (15-25)	
% Attribute 2+3 individuals	≥ 10% (5-15)	
% Attribute 5 individuals	≤ 70% (65-75)	
% Most dominant Attribute 5 individual	≤ 60% (55-65)	
BCG Level 5	**rule**	
# Total taxa	≥ 8 (6-10)	
% Attribute 5 individuals	≤ 85% (80-90)	
% Most dominant Attribute 5 individual	≤ 70% (65-75)	

The rules, which follow the observations shown in Figure 6, follow a general pattern of decreasing richness of sensitive taxa and increasing relative abundance of tolerant individuals as biological condition degrades. There are 6 quantitative rules for BCG level 2 samples. Nineteen or more total taxa must be present, the percent of highly sensitive (Attribute 2) taxa must be 8% or greater, the percent Attribute 2 individuals must be 3% or higher, sensitive (Attribute 2+3) taxa must comprise at least half of the assemblage, percent Attribute 2+3 individuals must be

60% or higher and fewer than 15 percent of the individuals in BCG level 2 samples may be tolerant (Attribute 5) (Table 6).

BCG level 3 sites have the same threshold for total taxa richness (19) as BCG level 2 sites, but the thresholds for the sensitive and tolerant taxa metrics were adjusted so that fewer sensitive taxa are required and more tolerant taxa are allowed. At BCG level 3 sites, the percent sensitive (Attribute 2+3) individuals must comprise 40% or more of the assemblage. In addition, there are two sets of alternate rules (one of these sets must be met). Either highly sensitive (Attribute 2) taxa must be present, percent sensitive (Attribute 2+3) taxa must be 45% or higher and tolerant (Attribute 5) individuals must be less than 50% OR the percent of sensitive (Attribute 2+3) taxa must be 25% or higher, fewer than 40% tolerant (Attribute 5) individuals must present and the most dominant Attribute 5 taxon must comprise less than 20% of the assemblage.

BCG level 4 is characterized by decreased taxa richness and greater presence of tolerant taxa. At least 15 total taxa must be present, and BCG level 4 rules require assemblages to have at least 20% sensitive (Attribute 2+3) taxa and 10% or more Attribute 2+3 individuals. The percent tolerant individuals (Attribute 5) must not exceed 70% and the most dominant Attribute 5 taxon must comprise less than 60% of the assemblage.

In BCG level 5 samples, the total taxa richness threshold is further reduced, with a requirement for 8 or more total taxa. Percent tolerant individuals (Attribute 5) must not exceed 85% and the most dominant Attribute 5 taxon must comprise less than 70% of the assemblage. BCG level 6 is discriminated from BCG level 5by a further reduction in taxa richness and greater dominance by tolerant (Attribute 5) individuals.

3.4 Model Performance

To evaluate the performance of the 46-sample calibration dataset and the 14-sample confirmation dataset, we assessed the number of samples where the BCG decision model's nominal level exactly matched the panel's majority choice ("exact match") and the number of samples where the model predicted a BCG level that differed from the majority expert opinion ("anomalous" samples). Then, for the anomalous samples, we examined how big the differences were between the BCG level assignments, and also whether there was a bias (e.g., did the BCG model consistently rate samples better or worse than the panelists).

Two types of ties were taken into account: 1) BCG model ties, where there is nearly equal membership in 2 BCG levels (e.g., membership of 0.5 in BCG level 2 and membership of 0.5 in BCG level 3); and 2) panelist ties, where the difference between counts of panelist primary and secondary calls is less than or equal to 1 (e.g., 4-4, or 5-4 decisions). If the BCG model assigned a tie, and that tie did not match with the panelist consensus, we considered this to be a difference of half a BCG level (e.g., if the BCG model assignment was a BCG level 2/3 tie and panelist consensus was a BCG level 2, the model was considered to be 'off 'by a half BCG level; or more specifically, the model rating was ½ BCG level worse than the panelists' consensus). The BCG model was also considered to differ by a half level if the panelists assigned a tie and the BCG model did not.

Results show that the Northern Piedmont BCG model for macroinvertebrates performs well. It is within a half BCG level or better on 95.7% of the calibration samples and 92.9% of the confirmation samples (Table 7). There are 2 anomalous samples in the calibration dataset. For both, the group consensus was BCG level 3 and the model assigned them to BCG level 2 (or '1 better'). With the one anomalous sample in the confirmation dataset, the model assigned the sample to a BCG level that was 1 worse than the group consensus. When half levels are considered, the BCG model differs by a half level on 3 samples, and with all 3, the BCG model rates the sample a half level worse than the panelists (Table 7).

Closer examination of the anomalous samples shows that the model is fairly close to agreement with panelists' consensus calls, or that the anomalous samples have unique characteristics that the BCG model may not be not be calibrated to fully capture. For example, one of the samples that differed by 1 BCG level (Samp047, Site BCBC211) was collected late in the index period (April 29, 1999), and Chironomidae were identified to the family versus the subfamily or tribe-level (nearly all samples in the calibration dataset had Chironomidae identified to the subfamily or tribe-level). Based on the panelists' calls, this sample is a 'borderline' BCG level 2/3 sample (meaning that there was a fairly even split between BCG level calls of 2- and 3+). At the time this sample was assessed, Chironomidae was assigned to BCG attribute 5. However, during a later round, it was determined that it would be more appropriate to make Chironomidae a BCG attribute 4 taxon, since the subfamilies and tribes have an average attribute assignment of 4, and also because Chironomidae were 'noninformative' as a family when panelists were making their assessments. If this sample were reassessed with Chironomidae listed as a BCG attribute 4 taxon, it is possible that the majority of panelists may call this a BCG level 2 sample. Regardless, the model output of 2 is close to the panelist consensus of a 'borderline' BCG level 2/3 sample.

The group consensus on the second anomalous calibration sample (Samp052, LOCH-120-S-2009) is also close to the BCG model output. The majority of panelists rated this as a high quality BCG level 3 sample (3+), while some gave it a 2-. The model assigned this to BCG level 2. Panelists cited the prevalence of *Prosimulium*, uncertainty about the unidentified Perlodidae and the low numbers of Attribute 2 taxa (2 of the 3 highly sensitive taxa occurred as single individuals) as reasons for keeping the group consensus at a BCG level 3 instead of a 2.

The anomalous sample in the confirmation dataset (Samp061, Site LSTM111, collection date 3/29/2012) has unique characteristics that the BCG model may not fully capture. It is extremely small, with a drainage area of 0.16 mi^2, is spring-fed and supports cold water taxa. The majority of panelists assigned this sample to BCG level 3 and the model assigned it to BCG level 4. The sample narrowly missed the BCG level 3 threshold for the % Attribute 2+3 individuals metric (the model threshold is 40%, and the metric value for this sample was 36%).

Table 6. Model performance for macroinvertebrate calibration and confirmation samples.

Difference (model vs. panel consensus call)	Calibration		Confirmation	
	Number	Percent	Number	Percent
model - 1 better	2	4.3	0	0.0
model - 1/2 better	0	0.0	0	0.0
exact match	43	93.5	11	78.6
model - 1/2 worse	1	2.2	2	14.3
model - 1 worse	0	0.0	1	7.1
Total # Samples	**46**	**100**	**14**	**100**

4 DECISION RULES AND BCG MODELS FOR FISH & SALAMANDERS

The fish/salamander BCG models were calibrated using MO DEP and MBSS samples. Models were calibrated for 3 drainage area-based stream size classes: small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and larger (> 8 mi^2). During the calibration exercise, panelists made BCG level assignments on 52 samples. In order to confirm the model, panelists made BCG level assignments on 13 additional samples. BCG level assignments for these 65 samples are summarized in Appendix J.

4.1 Site Assignments and BCG Level Descriptions

The group assigned fish/salamander samples to 5 BCG levels (BCG levels 2-6). Most of the samples are in the small and medium size classes (Table 8). Locations of the assessed sites are shown in Figure 7. Of the 65 samples that were assessed, 2 were assigned to BCG level 2. Both of these samples are in the small size class. As with the macroinvertebrate samples, the majority of samples were assigned to BCG levels 3 and 4 (Table 8).

Table 7. Number of calibration and confirmation fish samples that were assessed, organized by BCG level (group consensus). Models were calibrated for 3 drainage area-based stream size classes: small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and larger (> 8 mi^2).

BCG level	Calibration			Confirmation		
	Small	Medium	Large	Small	Medium	Large
1	0	0	0	0	0	0
2	2	0	0	0	0	0
3	9	8	5	3	2	1
4	6	11	1	2	2	0
5	4	4	0	0	1	0
6	1	1	0	2	0	0
Totals	*22*	*24*	*6*	*7*	*5*	*1*

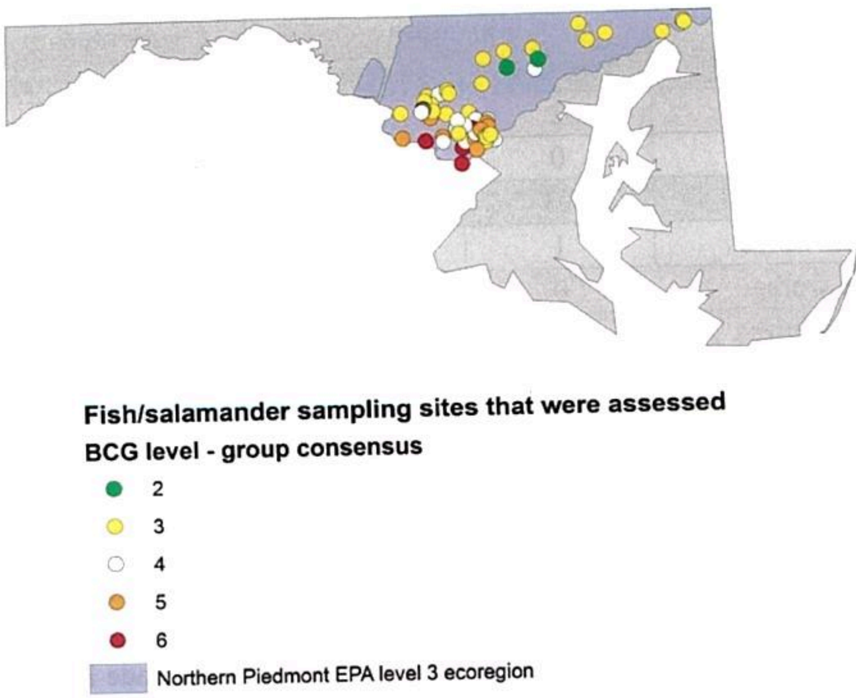

Figure 7. Locations of assessed fish samples, coded by panelist BCG level assignment.

4.2 BCG Attribute Metrics

Examinations of taxonomic attributes among the BCG levels determined by the panel showed that several of the attributes are useful in distinguishing levels, and indeed, were used by the panel's biologists for decision criteria. The most important considerations were percent individual and percent taxa metrics for sensitive (Attribute 1, 2, 3) and tolerant (Attribute 5, 6t) organisms. Box plots showing the distributions of these metrics across the 5 BCG levels are shown in Figure 8.

As shown in Figure 8, the Attribute 1+2+3 percent taxa metric discriminates well across all BCG levels. The Attribute 2+3 and Attribute 5 metrics generally show monotonic patterns, with Attribute 5 and 6t metrics increasing and Attribute 1+2+3 metrics decreasing as the assigned BCG level goes from 2 to 6. The percent Attribute 1+2+3 individuals metric discriminates particularly well between BCG levels 3, 4 and 5, and the tolerant metrics effectively discriminate BCG level 6 samples. When plotted against stream size, the total richness metric showed a relatively monotonic pattern, which is expected since more species are expected to naturally be present as streams increase in size (Figure 9).

It should be noted that the percent Attribute 5 individuals metric was fairly high in the BCG level 2 samples (Figure 8). The two BCG level 2 sites are small streams with brook trout. These were the only samples in the dataset that had brook trout. The percent Attribute 5 individuals metric was fairly high in these 2 samples because blacknose dace and creek chub, which are both attribute 5 taxa, naturally occur in high abundances in small to medium-sized streams that support brook trout. Box plots of additional metrics can be found in Appendix K.

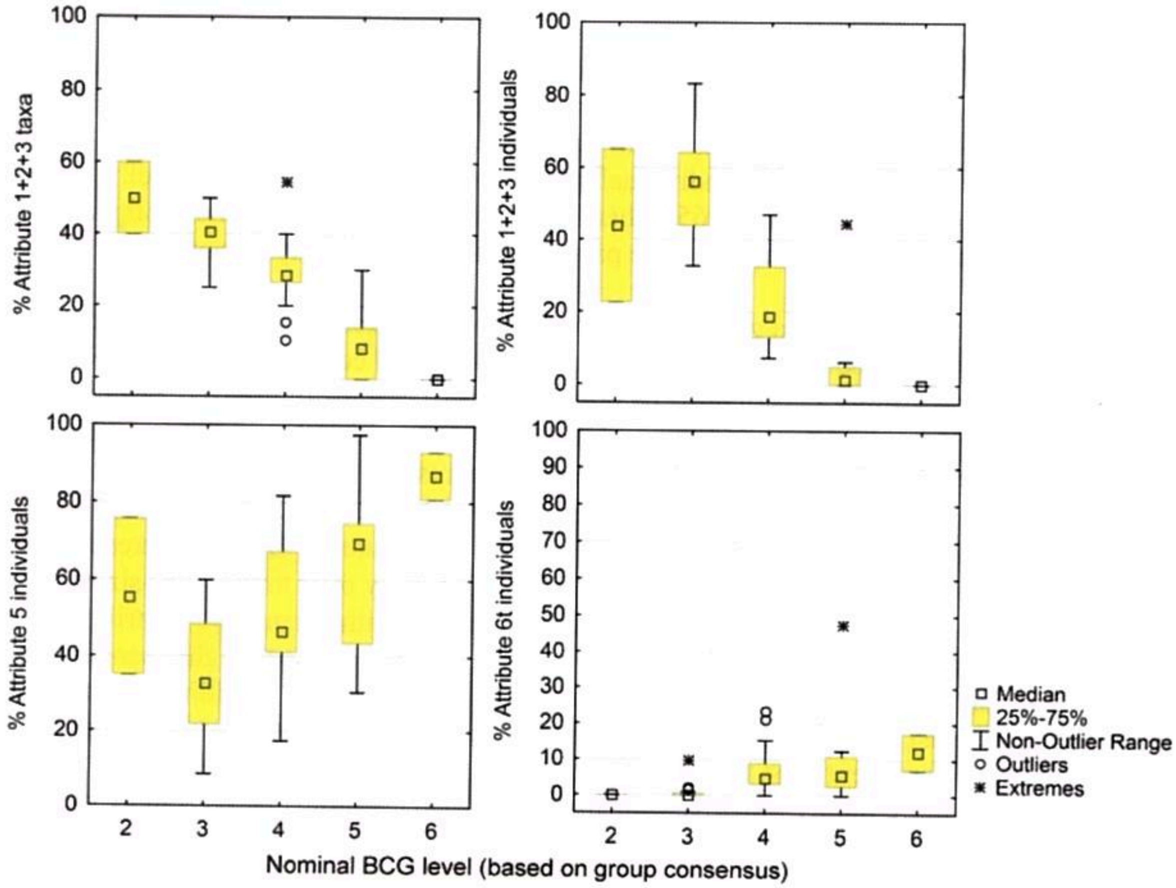

Figure 8. Box plots of sensitive (Attribute 2+3) and tolerant (Attribute 5 and 6t) percent taxa and percent individual metrics for fish calibration samples, grouped by nominal BCG level (group majority choice). Sample sizes for each BCG level are summarized in Table 8.

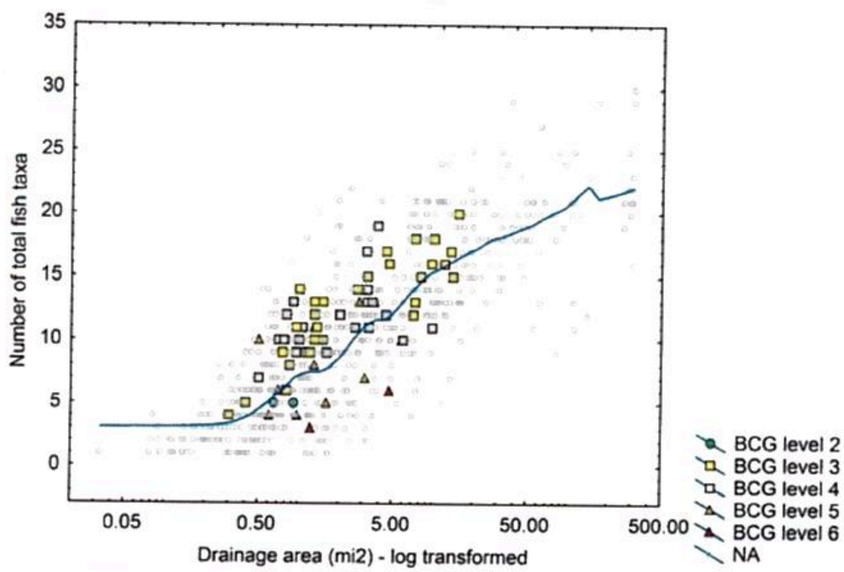

Figure 9. Relationship between total taxa metric values and watershed area, fit with a Lowess trend line. Samples are coded by nominal BCG level (group majority choice).

4.3 BCG Rule Development

The rules shown in Table 9 have been developed for distinguishing BCG levels for streams based on fish and salamander assemblages. Separate models were developed for small (0.5 to 1.4 mi^2), medium (1.5 – 7.9 mi^2) and larger (> 8 mi^2) streams. The rules were derived from discussions with the panelists on why individual sites were assessed at a certain level. The rules were calibrated and confirmed with the 65 fish/salamander samples rated by the group, and were adjusted so that the model would replicate the panel's decisions as closely as possible.

The fish/salamander rules follow a general pattern of decreasing richness of sensitive taxa and increasing relative abundance of tolerant individuals as biological condition degrades. Sensitive, regionally endemic (Attribute 1) taxa must be present at small and medium-sized BCG level 2 sites. Brook trout is the only Attribute 1 taxon that occurs in this dataset, and they werepresent in only 2 samples. The other BCG level 2 rules for small streams require either sensitive (Attribute 1+2+3) fish or salamander taxa to be present, percent Attribute 1+2+3 taxa to comprise 35% or more of the assemblage, fewer than 3 non-native tolerant (Attribute 6t) taxa to be present and percent Attribute 6t individuals to be 5% or less. These rules carry over to medium-sized streams, with the exception of the rule requiring the presence of either sensitive (Attribute 1+2+3) fish or salamander taxa. In medium-sized streams, either 2 or more highly sensitive (Attribute 1+2) fish taxa or 1 sensitive salamander taxa must be present. In addition, Attribute 1+2+3 individuals must comprise 50% or more of the assemblage and catadromous fish (Attribute 10) must be present. The BCG level 2 rules for medium-sized streams apply to larger streams, except that more highly sensitive (Attribute 1+2) fish taxa must be present (4 vs. 2), and there is no alternate rule for sensitive salamanders.

At small BCG level 3 sites, 2 or more sensitive (Attribute 1+2+3) fish taxa must be present, percent Attribute 1+2+3 taxa must comprise 25% or more of the assemblage, fewer than 3 non-native tolerant (Attribute 6t) taxa must be present, percent Attribute 6t individuals must be 15% or less and mid-water cyprinid taxa (notropis, luxilus, clinostomus and cyprinella, minus swallowtail shiners) must be present. In medium-sized BCG level 3 streams, sensitive (Attribute 1+2+3) fish taxa are not required to be present, but the other rules carry over, with the exception that the threshold for the mid-water cyprinid rule increases from 1 to 2. In addition, 25% or more of the fish taxa in medium-sized BCG level 3 streams must be sensitive (Attribute 1+2+3). The medium-sized rules apply to larger streams, with the following exceptions: 1 or more highly sensitive (Attribute 1+2) taxa must be present, fewer than 15% of the assemblage can be comprised of tolerant (Attribute 5) individuals and there is no rule for Attribute 6t taxa.

BCG level 4 sites have 3 rules. Sensitive (Attribute 1+2+3) fish taxa must be present, and the percent most dominant tolerant (Attribute 5 or 6t) taxon must comprise less than 65% of the assemblage. In addition, in small streams, at least 5% of the individuals must be sensitive (Attribute 1+2+3), and in medium and larger-sized streams, this threshold increases to 10%. Number of total taxa and number of total individuals are used to distinguish BCG level 5 samples. For all 3 size classes, there must be at least 4 total taxa and 100 total individuals. In addition, in medium and larger-sized streams, there must be fewer than 65% tolerant (Attribute 5+6t) taxa and fewer than 90% tolerant (Attribute 5+6t) individuals.

Table 8. BCG quantitative decision rules for fish assemblages in small (0.5 to 1.4 mi²), medium (1.5 – 7.9 mi²) and larger streams (> 8 mi²). The numbers in parentheses represent the lower and upper bounds of the fuzzy sets (for more details, see Section 2.1.3). The mid-water cyprinid taxa metric is comprised of notropis, luxilus, clinostomus and cyprinella, minus swallowtail shiners.

BCG Level 2	Small		Medium		Large
	rule	alt rule	rule	alt rule	rule
# Attribute 1 taxa	> 0 (present)		> 0 (present)		--
# Attribute 1+2 taxa	--		≥ 2 (1-4)		≥ 4 (2-6)
# Attribute 1+2+3 taxa	> 1 (0-3)	--	--		--
# Sensitive salamander taxa (if surveyed)	--	> 0	--	> 0	--
% Attribute 1+2+3 taxa	≥ 35% (30-40)		≥ 35% (30-40)		≥ 35% (30-40)
% Attribute 1+2+3 individuals	--		≥ 50% (45-55)		≥ 50% (45-55)
# Attribute 6t taxa	≤ 2 (1-3)		≤ 2 (1-3)		≤ 2 (1-3)
% Attribute 6t individuals	≤ 5% (3-7)		≤ 5% (3-7)		≤ 5% (3-7)
# Attribute 10 taxa	--		> 0		> 0
BCG Level 3	**Small**		**Medium**		**Large**
# Attribute 1+2 taxa	--		--		≥ 1 (0-2)
# Attribute 1+2+3 taxa	≥ 2 (0-4)		--		--
% Attribute 1+2+3 taxa	--		≥ 25% (20-30)		≥ 25% (20-30)
% Attribute 1+2+3 individuals	≥ 25% (20-30)		≥ 25% (20-30)		≥ 25% (20-30)
% Attribute 5 individuals	--		--		≤ 40% (35-45)
# Attribute 6t taxa	≤ 2 (1-4)		≤ 2 (1-4)		--
% Attribute 6t individuals	≤ 15% (10-20)		≤ 15% (10-20)		≤ 15% (10-20)
# Mid-water cyprinid taxa	> 0		> 1		> 1
BCG Level 4	**Small**		**Medium**		**Large**
# Attribute 1+2+3 taxa	> 1 (0-3)		> 1 (0-3)		> 1 (0-3)
% Attribute 1+2+3 individuals	≥ 5% (3-7)		≥ 10% (7-13)		≥ 10% (7-13)
% Most dominant Attribute 5a or 6t individual	≤ 65% (60-70)		≤ 65% (60-70)		≤ 65% (60-70)
BCG Level 5	**Small**		**Medium**		**Large**
# Total taxa	> 4 (3-6)		> 4 (3-6)		> 4 (3-6)
# Total individuals	> 100 (90-110)		> 100 (90-110)		> 100 (90-110)
% Attribute 5+6t taxa	--		≤ 65 (60-70)		≤ 65 (60-70)
% Attribute 5+6t individuals	--		≤ 90 (85-95)		≤ 90 (85-95)

4.4 Model Performance

To evaluate the performance of the 52-sample calibration dataset and the 13-sample confirmation dataset, we assessed the number of samples where the BCG decision model's nominal level exactly matched the panel's majority choice and the number of anomalous samples, or samples where the model predicted a BCG level that differed from the majority expert opinion. Then, for the anomalous samples, we examined how big the differences were between the BCG level assignments, and also whether there was a bias (e.g., did the BCG model consistently rate samples better or worse than the panelists). Ties were taken into account as described in Section 3.4.

The Northern Piedmont BCG models for fish/salamander assemblages performs well, matching within a half BCG level or better with the panelist consensus assignments on 100% of the calibration samples and 92.3% of the confirmation samples (Table 10). In the confirmation dataset, there is 1 sample that differs by 1 BCG level (Samp064, Station LSLS206, collection year 2013, small size class). The majority of panelists assigned this sample to BCG level 3 and the model assigned it to BCG level 4 ('1 worse'). The model assigned this sample to BCG level 4 because it fails the BCG level 3 rule that requires the presence of mid-water cyprinid taxa ((notropis, luxilus, clinostomus and cyprinella, minus swallowtail shiners). This is the only BCG level 3 sample to fail this rule, so we did not feel that a rule change was warranted. In the calibration dataset, the BCG model differs by a half level on 2 samples. With one, the BCG model rates the sample a half level worse than the panelists, and with the other, a half level better (Table 10.)

Table 9. Model performance for fish/salamander calibration and confirmation samples.

Difference (model vs. panel consensus call)	Calibration		Confirmation	
	Number	Percent	Number	Percent
model - 1 better	0	0.0 %	0	0.0 %
model - 1/2 better	1	1.9 %	0	0.0 %
exact match	50	96.2 %	12	92.3 %
model - 1/2 worse	1	1.9 %	0	0.0 %
model - 1 worse	0	0.0 %	1	7.7 %
Total # Samples	**52**	**100 %**	**13**	**100 %**

5 DESCRIPTION OF ASSEMBLAGES IN EACH BCG LEVEL

When panelists assess samples, they often associate particular taxa (and abundances of these taxa) with certain BCG levels. In Table 11, we provide narrative descriptions of each of the BCG levels that were assessed during this exercise (modified after Jackson et al. 2013), as well as lists of fish, salamander and macroinvertebrate taxa that were commonly found in samples from each BCG level. Pictures of some of the important aquatic species that occur in Maryland's Northern Piedmont headwater streams are shown in Figure 10.

Table 10. Description of fish, salamander and macroinvertebrate assemblages in each assessed BCG level. Definitions are modified after Davies and Jackson (2006).

BCG level 1	**Definition:** Natural or native condition - *native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability*
	Narrative from expert panel: There are no BCG Level 1 sites within the Piedmont. All sites have some degree of disturbance, including legacy effects from agriculture and forestry from 100 to 200 years ago. Conceptually, BCG Level 1 sites would have strictly native taxa for all assemblages evaluated (fish, salamander, benthic macroinvertebrates), some endemic species, and evidence of connectivity in the form of migratory fish.
	Fish: Examples of endemic species that might be present (depending on the size of the stream) include: Bridle Shiner, Brook Trout, Chesapeake Logperch, Maryland Darter, Trout Perch
	Macroinvertebrates: Sensitive-rare, cold water indicator taxa such as the mayfly Epeorus, and stoneflies Sweltsa and Talloperla are expected to be present
BCG level 2	**Definition:** Minimal changes in structure of the biotic community and minimal changes in ecosystem function - *virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability*
	Narrative from expert panel: Overall taxa richness and density is as naturally occurs (watershed size is a consideration). These sites have excellent water quality and support habitat critical for native taxa. They have many highly sensitive taxa and relatively high richness and abundance of intermediate sensitive-ubiquitous taxa. Many of these taxa are characterized by having limited dispersal capabilities or are habitat specialists. If tolerant taxa are present, they occur in low numbers. There is connectivity between the mainstem, associated wetlands and headwater streams.
	Fish: Highly sensitive (Attribute II) and intermediate sensitive (Attribute III) taxa such as yellow perch, northern hog sucker, margined mad tom, fallfish and fantail darter are present, as are native top predators (e.g., brook trout). Migratory fish and amphibians (e.g., eel, lamprey, salamanders) are present or known to access the site. Long-tailed and Dusky salamanders are also good indicators, given a complimentary fish community. Non-native taxa such as brown trout or rainbow trout, are absent or, if they occur, their presence does not displace native trout or alter structure and function.
	Macroinvertebrates: Highly sensitive taxa are present - especially coldwater indicator mayflies, stoneflies, and caddisflies (e.g, Epeorus, Paraleptophlebia, Sweltsa, Tallaperla and Wormaldia) - and occur in higher abundances than in BCG level 3 samples.

Table 11 continued...

BCG level 3	**Definition:** Evident changes in structure of the biotic community and minimal changes in ecosystem function - *Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but intermediate sensitive taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system*
	Narrative from expert panel: Generally considered to be in good condition. Similar to BCG level 2 assemblage except the proportion of total richness represented by rare, specialist and vulnerable taxa is reduced. Intermediate sensitive-ubiquitous taxa have relatively high richness and abundance. Taxa with intermediate tolerance may increase but generally comprise less than half total richness and abundance. Tolerant taxa are somewhat more common but still have low abundance. Taxa with slightly broader temperature or sediment tolerance may be favored.
	Fish: Intermediate sensitive (Attribute III) taxa such as fallfish and fantail darter are common or abundant. Taxa of intermediate tolerance (Attribute IV) such as channel catfish, least brook lamprey, pumpkinseed and tessellated darter are present in greater numbers than in BCG level 2 samples. Some tolerant (Attribute V) taxa such as mummichog and white suckers may be present, but highly tolerant taxa are absent. Pioneering speices such as blacknose dace, creek chubs and white suckers may be naturally common in smaller streams. Migratory species such as American Eel may be absent. Two-lined salamanders may occur.
	Macroinvertebrates: Similar to BCG level 2 assemblage except sensitive taxa (e.g, Sweltsa, Tallaperla and Wormaldia) occur in lower numbers. Level 3 indicator taxa include the caddisfly Diplectrona, the mayfly Ephemerella and the stonefly Amphinemura.
BCG level 4	**Definition:** Moderate changes in structure of the biotic community and minimal changes in ecosystem function - *Moderate changes in structure due to replacement of some intermediate sensitive taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*
	Narrative from expert panel: Sensitive species and individuals are still present but in reduced numbers (e.g., approximately 10 – 30% of the community rather than 50% found in Level 3 streams). The persistence of some sensitive species indicates that the original ecosystem function is still maintained albeit at a reduced level. Densities and richness of intermediate tolerance taxa have increased compared to BCG level 3 samples.
	Fish: 2 or 3 sensitive taxa may be present but occur in very low numbers (e.g., Blue Ridge Sculpin, Fantail Darter, Potomac Sculpin, Fallfish, Rosy-side Dace, River Chub). Taxa of intermediate tolerance (Attribute IV) such as tesselated darter, least brook lamprey, longnose dace are common, as well as tolerant taxa like yellow bullhead, red-breast sunfish and bluntnose minnow. Level 4 streams may harbor 2 to 3 salamander species (Dusky, Red, and Two-lined).
	Macroinvertebrates: Sensitive taxa (including EPT taxa) are present but occur in low numbers. Taxa such as Diplectrona and Dolophilodes may occur, but other key taxa such as Ephemerella and Neophylax are absent. Taxa of intermediate tolerance (e.g., Baetis, Stenonema, Caenis, Chimarra, Cheumatopsyche, Hydropsyche) occur in greater numbers. Tolerant taxa such as Chironomini and Orthocladiinae are present but do not exhibit excessive dominance.

Table 11 continued...

BCG level 5	**Definition:** Major changes in structure of the biotic community and moderate changes in ecosystem function - *Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials*
	Narrative from expert panel: Overall abundance of all taxa reduced. Sensitive species may be present but their functional role is negligible within the system. Those sensitive taxa remaining are highly ubiquitous within the region and have very good dispersal capabilities. The most abundant organisms are typically tolerant or have intermediate tolerance, and there may be relatively high diversity within the tolerant organisms. Most representatives are opportunistic or pollution tolerant species.
	Fish: Facultative species reduced or absent. Tolerant taxa like yellow bullhead, red-breast sunfish, and bluntnose minnow are common. Blacknose dace, creek chubs and white suckers may dominate. Two-lined salamanders might be the only salamander present.
	Macroinvertebrates: Highly sensitive macroinvertebrate taxa are usually absent and Chironomid midges (mostly tolerant Orthocladiinae and Chironomini) often comprised >50% of the community in Level 5 streams.
BCG level 6	**Definition:** Major changes in structure of the biotic community and moderate changes in ecosystem function - *Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials*
	Narrative from expert panel: Heavily degraded from urbanization and/or industrialization. Can range from having no aquatic life at all or harbor a severely depauperate community composed entirely of highly tolerant or tolerant invasive species adapted to hypoxia, extreme sedimentation and temperatures, or other toxic chemical conditions.
	Fish: Fish are low in abundance or absent, represented mainly by blacknose dace, green sunfish, bluntnose minnow or creek chub.
	Macroinvertebrates: May be dominated by tolerant non-insects (Physid snails; Planariidae; Oligochaeta; Hirudinea; etc.)

Figure 10. Important aquatic species in Maryland's Piedmont headwater streams. Salamanders (Long-tailed, Dusky, and Red); fishes (Potomac Sculpin, Rosyside Dace, American Eel); Insects (Sweltsa, Paraleptophlebia, Ephemerella).

6 DISCUSSION

Aquatic biologists from MO DEP, the State of Maryland, the University of Maryland, University of Maryland at Baltimore County, the Interstate Commission Potomac River Basin, US EPA and the states of Virginia, Pennsylvania and Delaware partnered to develop a common assessment system based on the BCG for macroinvertebrate, fish and salamander assemblages in streams in the Northern Piedmont of Maryland. This was a collective exercise among regional biologists to develop consensus on assessments of samples. We elicited the rules that the biologists used to assess the samples, and developed a set of quantitative decision criteria rules for assigning samples to BCG levels. The biologists working on the macroinvertebrate samples assessed samples independently from the panelists working on the fish and salamander samples.

The fish and macroinvertebrate BCG models performed well, scoring within a half BCG level or better on at least 95% of the calibration samples and on 92% on the confirmation samples. Several sites were assigned to BCG level 2, which, based on participants' input, represent the present-day highest quality waters in this region. Moving ahead, MO DEP and MDDNR could potentially use the BCG models to supplement the IBI measures that they currently use to assess stream health. As new data are collected, BCG model outputs can be generated using the electronic worksheets that accompany this report. If the BCG models are utilized, users should consider the limitations of the models. Results from the fish/salamander model should be interpreted with caution if it is applied to streams with drainage areas of 0.5 square miles or less.

The macroinvertebrate BCG model outputs should be interpreted with caution and checked using professional assessment if: 1) samples are collected early or late in the index period; 2) if levels of taxonomy are inconsistent with those used in the calibration dataset (e.g., if Chironomidae are not identified to the subfamily or tribe-level); and 3) if there are more than 120 total individuals in the sample.

If the BCG models are used to supplement IBI measures, the BCG, as developed conceptually in Davies and Jackson (2006), addresses several limitations of existing biotic indexes. Advantages of the BCG include:

- The BCG is based on ecological considerations with wide expert agreement, rather than on empirical analysis of a particular data set. The resulting index is calibrated using a data set, but the result is intended to be more general than a regression analysis of biological response to stressors.

- The BCG uses universal attributes (Attributes 2 to 6) that are intended to apply in all regions. Specifics of the attributes (taxon membership, attribute levels indicating good, fair, poor, etc.) do vary across regions and stream types, but the attributes themselves and their importance are consistent.

- The BCG requires descriptions of the classes or levels, from pristine to degraded. While requiring extra work, this ensures that future information and discoveries can be related back to the baseline level descriptions. Levels are not perfect or static—they will be altered by increase in knowledge.

The BCG developed by the experts here may be more robust than current indexes because it allows, in some cases, for nonlinear responses. The BCG is not conceptually tied to "best available" sites as a reference condition. Although best available sites are used as a practical ground truth, it is recognized at the outset that these sites are typically less than pristine, and may be a lower level (e.g., 2, 3, 4).

The levels of the BCG are biologically recognizable stages in condition of stream waterbodies. As such, they can form a biological basis for criteria and regulation of a state's waterbodies. Current thresholds of narrative biocriteria in many states (usually an IBI score, or something similar) are relatively low (e.g., level 4-level 5), and fail to protect outstanding condition waters (levels 1 and 2), or even good condition waters (level 3). Thus, biocriteria set at a lower BCG level will allow incremental degradation of waterbodies to the regulatory level.

The BCG provides a powerful approach for an operational monitoring and assessment program, for communicating resource condition to the public and for management decisions to protect or remediate water resources. It allows practical and operational implementation of multiple aquatic life uses in a state's water quality criteria and standards. Adoption of the BCG as an assessment tool in the context of multiple Aquatic Life Uses (Tiered Uses) yields the technical tools for protecting the state's highest quality waters, as well as developing realistic restoration goals for urban and agricultural waters. States and tribes could use the BCG model to identify biological expectations for tiered aquatic life uses. Several of the stream sites in least-stressed catchments in this report were rated a BCG level 2 by the panel of biologists. The least-stressed catchments may also correspond to Outstanding or Exceptional waters (this would need to be confirmed).

In the future, the Northern Piedmont BCG models could potentially be expanded beyond Maryland to a regional scale. Regional BCG models that accommodate methodological differences have been developed for cold and cool streams in northern ecoregions of the Upper Midwest and for medium to high gradient streams in parts of New England (Stamp and Gerritsen 2009, Gerritsen and Stamp 2012). The New England model is for macroinvertebrates and is cross-calibrated for methods used by biomonitoring programs in Maine, New Hampshire, Vermont and Connecticut, as well as for US EPA National Rivers and Streams Assessment protocols. The Northern Forest models were developed for macroinvertebrate and fish assemblages for Indian Reservations and the states of Michigan, Wisconsin, and Minnesota. If a similar framework were developed for the Northern Piedmont, the Maryland BCG models would serve as a good starting point.

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Jackson, Susank

From:	Jackson, Susank
Sent:	Wednesday, February 05, 2014 9:41 AM
To:	Van Ness, Keith
Cc:	Pond, Greg; Stranko, Scott; Gerritsen, Jeroen; Reynolds, Louis
Subject:	Meeting Update Fact Sheet-edit re temp and restoration of native fish
Attachments:	Piedmont_BCG_Expert_Meeting_Update_for_MoCo_Feb_4.docx

I have revised the meeting summary 'fact sheet' to address comment from Scot asking about temp data in regards to reintroduction of brook trout. Keith - is there existing temp data that indicate, or not, the temp regime necessary to support re-introduction? I have edited the fact sheet to indicate temp regime is a consideration in re-introduction.

The reason I am asking this is because I have received a specific question on this from a citizen who wants to talk with Berliner.

Susan

Expert Meeting Update: Condition Assessment of Ten Mile Creek Watershed Streams_2/4/14 draft

In March 2013, Montgomery County convened a panel of 17 scientists with expertise in stream ecology, benthic macroinvertebrate (e.g. insects, crayfish, mussels, snails, and worms) and fish community assessments. The experts attending the meeting included scientists from Montgomery County, the State of Maryland, the University of Maryland, University of Maryland at Baltimore County, the Interstate Commission Potomac River Basin and U.S. EPA. The purpose of this meeting was to develop and test a preliminary model for assessment and interpretation of the biological condition of streams within the Ten Mile Creek (TMC) Watershed. A preliminary model was developed using taxonomic data provided by the county and the Maryland Biological Streams Survey (MBSS). The model, Piedmont Biological Condition Gradient, provides a framework for assessing current stream condition relative to natural, undisturbed conditions and identifying goals for protection of high quality streams and restoration of degraded streams (US EPA 810-R-11-01).

On September 24 – 26, 2013 Montgomery County convened a second expert meeting with a larger number of sites for analysis and with an expanded group of experts, including scientists from the states of Virginia, Pennsylvania and Delaware. A more robust and in-depth analysis of the sites is necessary to refine the model developed in the spring and develop an approach for quantification of the model. The preliminary findings of both expert meetings were comparable:

- Four of the 11 Ten Mile Creek monitoring stations were used in the development of the model. One headwater site within the TMC Watershed (King Spring-LSTM110) was identified as a high quality stream (Tier 2-) with taxa comparable to State of Maryland Sentinel Sites (Figure 1). Impervious cover for these sites was at 3% or below. Three other TMC sites were rated between Tier 3 and Tier 4 (lower condition) and considered at risk for further degradation. Those sites that were approaching BCG level 4 were informally characterized as "hanging on" to what may be considered an acceptable level of condition. These sites are potential candidates for cost effective restoration to higher conditions.

- Sites within TMC Watershed (as well as within the larger Piedmont ecoregion) having higher levels of impervious surface were assessed as lower quality. These more degraded sites had elevated levels of specific conductance, an indicator of urban runoff. However, tributaries (like King Spring) serve to dilute specific conductance in the lower mainstem TMC.

- Sites within the Piedmont with levels of impervious surface typically higher than 4% showed increasingly degraded aquatic communities. Figure 2 shows average benthic tier assignment and % sensitive species plotted against % impervious surface.

- Across Montgomery County both fish and benthic macroinvertebrate assemblages are assesses. Invertebrates serve critical roles in stream ecosystem functioning in addition to providing food and energy to downstream vertebrate consumers such as fish and salamanders. In some instances, the experts tended to assign lower ratings for the fish community; this was generally attributed to prevention of native fish migration due to dams and other obstacles. Additionally, there was evidence of intrusion of lake fish species from reservoirs. However, there was sufficient fish habitat and food supply (the benthic macroinvertebrates) to support re-introduction of native species such as brooks trout or migration of other species such as eel. Depending upon existing temperature regimes, t~~T~~hese sites ~~are~~ may be excellent sites for re-introduction of native and migratory species.

Draft decision rules to consistently quantify the site assessments were developed and considered by experts to be applicable to the larger Piedmont region. The experts, including the Maryland, Virginia, Pennsylvania and Delaware state experts, agreed to collaborate in development of decision rules and an algorithm for model quantification. Analysis of new sites and testing of decision rules by the experts will be conducted over next few months. Some of the experts will further evaluate the relationship between flow, proposed stream BMPs and predicted biological impacts as it relates to their current research. The biological condition gradient model can be used to supplement the Montgomery County IBI to more precisely identify high quality conditions for protection and to establish incremental goals for restoration.

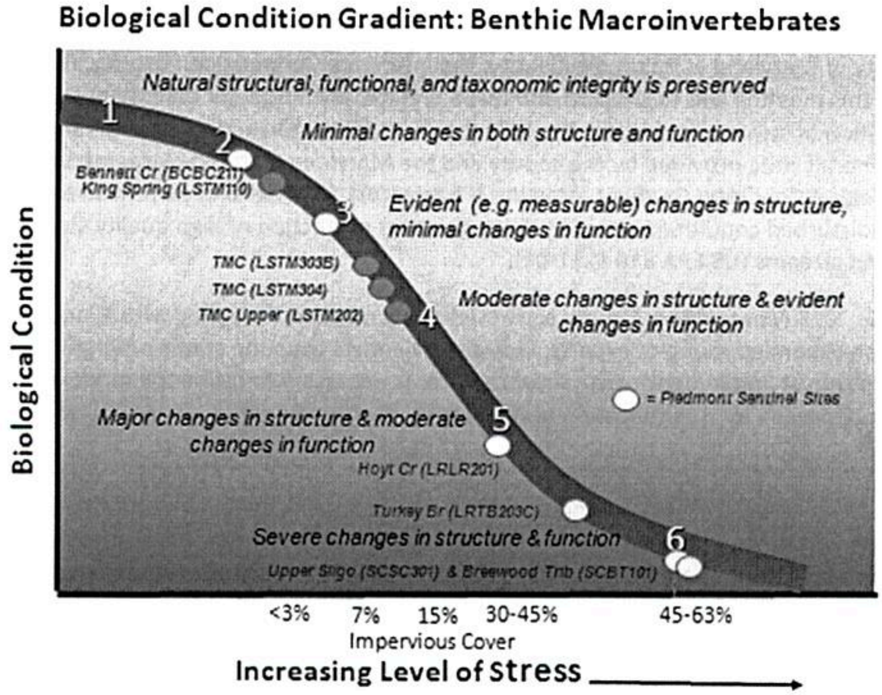

Figure 1. Comparative BCG assessment ratings of macroinvertebrates within Ten Mile Creek (LSTM) sites (blue dots), example Piedmont Sentinel Sites (light blue dots), and similar stream types with increased disturbance (yellow dots).Percent impervious surface for each site is noted along the stress axis.

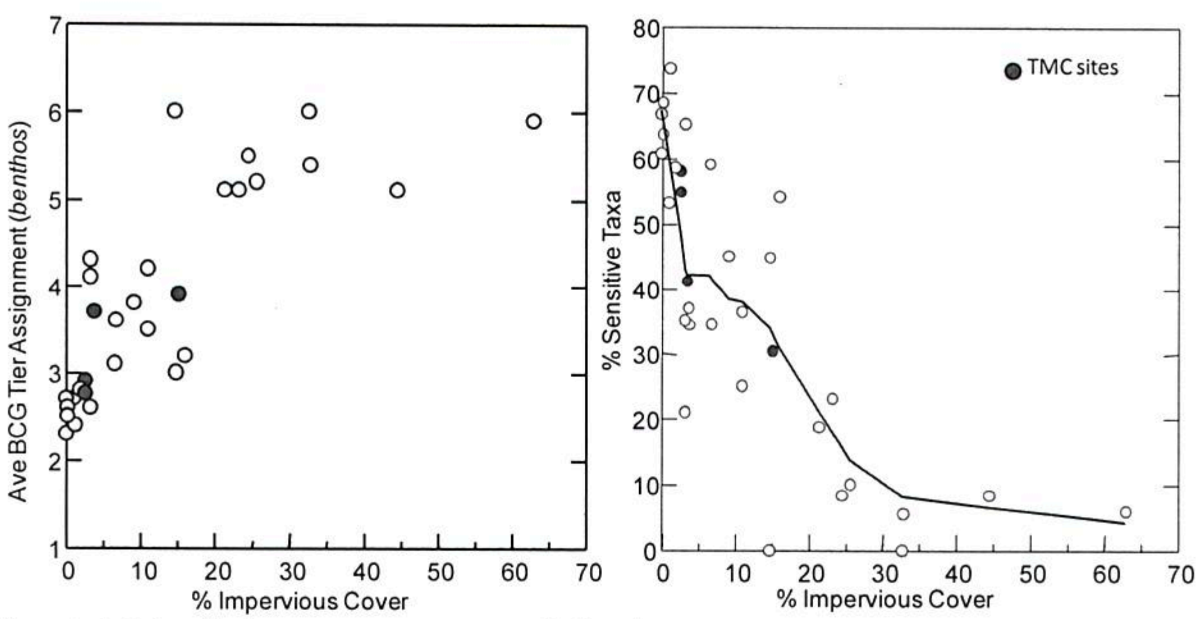

Figure 2. Relationship between average BCG tiers (left) and % Sensitive Taxa (right) versus % impervious cover. This analysis included all sites assessed at the second meeting and included sites from throughout the Piedmont Region in Maryland. Ten Mile Creek (TMC) sites are indicated (red dots).

FAQS

What was the correspondence between the stream sites considered "good quality" and the BCG model?

Sites assigned BCG levels 2 and 3 were considered excellent and good quality streams with presence of native and sensitive, sometimes rare, species of benthic macroinvertebrates, fish and/or salamanders. The relative abundance of these species was diminished in sites assessed at BCG level 4. The experts informally characterized these latter sites as "hanging on" to what may be considered an acceptable level of condition and, depending on type of disturbance and potential for BMPS, good candidates for restoration.

Are there comparable subsheds with similar scores whose land cover, slope and soil conditions are comparable to the TMC?

Maryland Biological Survey (MBSS) Sentinel sites (considered the "best" quality streams in the Piedmont) with similar watershed characteristics scored comparably to King Spring, a TMC site (LSTM110)). One of the Montgomery County sites in a different watershed that scored similarly high was Bennett Creek (BCBC211), another stream with relatively low development (3% impervious surface). Bennett Creek lies just to the north of Clarksburg (north of Little Bennett Creek). Although in a different drainage, this forest block is relatively contiguous with the TMC watershed though bisected by the I-270 corridor. The best fish communities among the Montgomery County samples were in the Upper Patuxent River, and the Clarksburg Tributary in 1998 (which has been subsequently degraded by development). Many of the same sensitive benthic invertebrate taxa collected at TMC sites are shared among Sentinel Sites indicating that many streams in the TMC watershed are in very good condition and some segments could be restored with re-introduction of selected species. However, the results of the expert analysis indicate that increasing development in the watershed will predictably result in loss of relative abundance of sensitive taxa (see Figure 2). By way of example, samples taken from three Montgomery County streams before and after development (Before: 1997-98; after: 2011-2012) showed a consistent decline of at least one BCG level (e.g. from Level 3 to 4 or from 4 to 5) over the period, for both invertebrates (3 streams) and for fish (2 streams). Sites rated between BCG levels 3 and 4 were considered by the experts as sites slipping towards degradation but with potential for cost effective restoration.

Did the new information and data analysis changed expert view of the TMC sheds rated before?

No. In fact, both the experts that attended the first meeting and those who were new and attended the second meeting assigned TMC sites with nearly identical assessment ratings. The experts were not informed that the sites had been previously assessed. The decision rules drafted at the meeting are based on the expert judgment and the science underlying the decision rules documented. These draft rules will be further tested and peer reviewed to development final model.

Jackson, Susank

From: Jackson, Susank
Sent: Wednesday, February 05, 2014 10:03 AM
To: Van Ness, Keith
Cc: Pond, Greg; Stranko, Scott; Gerritsen, Jeroen; Reynolds, Louis
Subject: RE: Meeting Update Fact Sheet-edit re temp and restoration of native fish

,

Is there a time I could talk with you today? I would like to send you the fact sheet and then refer councilman Ehrlich and public with questions to you to obtain the meeting update.

Susan

From: Jackson, Susank
Sent: Wednesday, February 05, 2014 9:41 AM
To: Van Ness, Keith
Cc: Pond, Greg; Stranko, Scott; Gerritsen, Jeroen; Reynolds, Louis
Subject: Meeting Update Fact Sheet-edit re temp and restoration of native fish

I have revised the meeting summary 'fact sheet' to address comment from Scot asking about temp data in regards to reintroduction of brook trout. Keith - is there existing temp data that indicate, or not, the temp regime necessary to support re-introduction? I have edited the fact sheet to indicate temp regime is a consideration in re-introduction.

The reason I am asking this is because I have received a specific question on this from a citizen who wants to talk with Berliner.

Susan

Jackson, Susank

From:	Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent:	Monday, June 30, 2014 1:53 PM
To:	Gerritsen, Jeroen; Jen.Stamp@tetratech.com
Cc:	Jackson, Susank; [redacted] tis, Meosotis
Subject:	RE: draft BCG report for the Northern Piedmont region of Maryland

Hi All:

Jeroen – the excel workbook that Jen already sent us is perfect! No need to make it 'user-friendly' just for me – our IT staff eat these codes for snacks! I discussed this with one of our IT folks just now and the excel workbook would be the best. We use SQL for our database and the excel can be brought in easily.

Thank you all again for this great tool – We look forward to using it. Our IT team has even promised to let me use it once they have a back-up copy.

Best wishes and thank you all again!
Keith

From: Gerritsen, Jeroen [mailto:Jeroen.Gerritsen@tetratech.com]
Sent: Wednesday, June 25, 2014 9:49 AM
To: Stamp, Jen; Van Ness, Keith
Cc: Jackson, Susank; [redacted]
Subject: RE: draft BCG report for the Northern Piedmont region of Maryland

Also, Keith, we have a mandate from Susan to get you a working calculation system (software) to calculate the BCG levels for new samples that Mo Co takes. This can be the Excel workbook that Jen already sent (modified to be user friendly as necessary), or we have an access application that we can modify for the MoCo /MBSS data.

What is MoCo's preference for this? How do you currently store and archive the monitoring data? If possible, we should set up a conference call or meeting to scope this out.

Thanks,

Jeroen

Jeroen Gerritsen
Tetra Tech, Inc.
400 Red Brook Blvd., Suite 200
Owings Mills, MD 21117
Direct: (410) 902-3149
Office: (410) 356-8993

From: Stamp, Jen
Sent: Monday, June 23, 2014 3:28 PM
To: Van Ness, Keith; Gerritsen, Jeroen
Subject: RE: draft BCG report for the Northern Piedmont region of Maryland

Hi Keith,
Wow that is excellent! I am so glad that you liked the report and didn't have any major edits.

I tried to make the Excel worksheets as simple as possible but unfortunately they are still complicated. Please let me know if the Instructions file needs to be improved.

Also, I wanted to follow up about your earlier email regarding the comparison of the IBI and BCG. I am glad you found that useful. We initially included those results in the report but then decided to pull that section out because sometimes comparisons like that get a bit touchy (sometimes people get into debates about which score – the IBI or BCG – is correct). Jeroen, do you have any further thoughts on that topic? Perhaps we'll reconsider if it comes up in other reviewers' comments.

Thanks,

Jen

From: Van Ness, Keith [mailto:Keith.VanNess@montgomerycountymd.gov]
Sent: Monday, June 23, 2014 12:49 PM
To: Stamp, Jen; Gerritsen, Jeroen; Pond.Greg@epa.gov; Reynolds, Louis; Jackson.Susank@epa.gov
Cc: Curtis, Meosotis
Subject: FW: draft BCG report for the Northern Piedmont region of Maryland

Hi Jen and Jeroen:
Well, I find myself in a situation that I have rarely been in. I have no edits or comments on the work you all have produced. I would not change anything. I find the document and all the appendices to be well written, understandable and to the point. The listing of the species starting on page 5 of Appendix B was a great addition as it helps me envision the biological community associated with each tier within the piedmont. Thank you so much for all this work! You all went far above what I thought was going to be provided and I thank you.

Now I have to find something I can edit and comment on! Your work certainly doesn't require my 'bull in the china shop' editing approach. Now I would like to review the excel spreadsheets you sent over that can be used to calculate the BCG model outputs – I may have questions on that!

Sincerely
Keith Van Ness

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Thursday, June 12, 2014 9:35 PM
To: Pond.Greg@epa.gov; EFriedman@dnr.state.md.us; Warren.Smigo@deq.virginia.gov; William.Shanabruch@deq.virginia.gov; Ellen.Dickey@state.de.us; mstover@mde.state.md.us; mbaker@umbc.edu; NDziepak@dnr.state.md.us; Matthew.Harper@montgomeryparks.org; David.Sigrist@montgomeryparks.org; aeverett@pa.gov; cluckett@mde.state.md.us; Jeanne.Classen@deq.virginia.gov; aleslie@umd.edu; cmswan@umbc.edu; agriggs@icprb.org; Jordahl, Dave; Alexander.Laurie@epa.gov; SSTRANKO@dnr.state.md.us; Reynolds.Louis@epa.gov; Jcummins@ICPRB.org; msoutherland@Versar.com; abecker@dnr.state.md.us; Jai.Cole@montgomeryparks.org; cpoukish@mde.state.md.us; borsuk.frank@epa.gov; Mack, Kenny; JKilian@dnr.state.md.us; St. John, Jennifer; Van Ness, Keith; cgougeon@dnr.state.md.us; Naibert, Eric; Jackson.Susank@epa.gov; Shofar, Steven; Curtis, Meosotis; mary.dolan@montgomeryplanning.org; mark.symborski@montgomeryplanning.org; Forren.John@epa.gov; DBOWARD@dnr.state.md.us
Cc: Gerritsen, Jeroen
Subject: draft BCG report for the Northern Piedmont region of Maryland

Hello members of the Northern Piedmont BCG working group,
Attached you'll find the draft BCG report for the Northern Piedmont region of Maryland. If you have an opportunity to provide comments on the report, we welcome your feedback. If possible, we ask that you send us your comments by **Friday June 27.**

In addition, in a separate email I will send out Excel worksheets that can be used to calculate BCG model outputs for new data.

Please let me know if you have any questions about the attached files.

Thank you! We greatly appreciate your participation in this project,

Jen and Jeroen

Jen Stamp | Aquatic Ecologist
Voice: 802.229.4508 (office) 802.839.8603 (cell)| Fax: 802.223.6551 Jen.Stamp@tetratech.com

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Jackson, Susank

From:	Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent:	Tuesday, July 08, 2014 8:14 AM
To:	Pond, Greg
Cc:	Mack, Kenny; Jen.Stamp@tetratech.com; Jackson, Susank; Gerritsen, Jeroen
Subject:	Re: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

We do need to rethink our sub sampling methods. Getting closer to 120 individuals is a start.

Sent from my iPhone

On Jul 7, 2014, at 5:19 PM, "Pond, Greg" <Pond.Greg@epa.gov> wrote:

> Thank you Kenny for these observations. I had sent Jen comments earlier that changed the wording on this in the methods section to recognize 100-150 organisms. In the second workshop, we did re-assess sites using 120 that previously had sometimes >300 organisms, to see if panelists would change their assessment. I don't believe we had a sample size of sites worth analyzing statistically but we did this for observational purposes only. The 120 computer subsample of MoCo data was absolutely necessary to strike a balance between MBSS and MoCo datasets. There were some samples that had >150, but I believe these were re-do's and I'm not sure they count, but Jen and Jeroen could confirm. To answer your question, I do not believe tiers would be correlated with increasing number of individuals, since the samples came from a variety of conditions (good, bad, ugly). That said, I wonder if it is worthwhile addressing those several samples in a paragraph that the panel re-assessed with the 120 standard subsample. My memory is that they did not change for nominal assignments but might have changed to a (+) or (-) within a tier ....
>
> Greg
>
> **From:** Mack, Kenny [mailto:Kenny.Mack@montgomerycountymd.gov]
> **Sent:** Monday, July 07, 2014 3:05 PM
> **To:** Jen.Stamp@tetratech.com
> **Cc:** Van Ness, Keith; Pond, Greg; Jackson, Susank; Gerritsen, Jeroen
> **Subject:** RE: seeking comments on draft BCG report for the Northern Piedmont region of Maryland
>
> Hi Jen,
>
> Sorry I didn't get back to you sooner, but I have had a chance to review the report and have two comments:
>
> 1) Jai Cole, Matt Harper, and Dave Sigrist work for *Maryland National Capital Park and Planning Commission* or *MNCPPC* (Page ii)
>
> 2) "The macroinvertebrate BCG model outputs should be interpreted with caution and checked using professional assessment if: 1) samples are collected early or late in the index period; 2) if levels of taxonomy are inconsistent with those used in the

calibration dataset (e.g., if Chironomidae are not identified to the subfamily or tribe-level); and 3) if there are more than 120 total individuals in the sample."

Was macroinvertebrate tier assignment correlated to number of individuals in the sample? After quickly glancing at the validation files it appears almost half of the sites assessed had more than 120 individuals, and those with 120 individuals contain only a subset of the original sample. In the discussion section (end of first paragraph on page 33) it says additional caution must be taken when a sample contains greater than 120 individuals. When should a subset of 120 individuals be used in place of the original sample? Were samples that were subsampled to 120 individuals found to have different tier assignments than those that were not reduced to 120 individuals?

Thanks,

Ken Mack
Aquatic Biologist
Montgomery County
Department of Environmental Protection
255 Rockville Pike
Rockville, MD 20850
240.777.7729

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Wednesday, July 02, 2014 1:30 PM
To: Pond.Greg@epa.gov; EFriedman@dnr.state.md.us; Warren.Smigo@deq.virginia.gov; William.Shanabruch@deq.virginia.gov; Ellen.Dickey@state.de.us; mstover@mde.state.md.us; mbaker@umbc.edu; NDziepak@dnr.state.md.us; Matthew.Harper@montgomeryparks.org; David.Sigrist@montgomeryparks.org; aeverett@pa.gov; cluckett@mde.state.md.us; Jeanne.Classen@deq.virginia.gov; aleslie@umd.edu; cmswan@umbc.edu; agriggs@icprb.org; Jordahl, Dave; Alexander.Laurie@epa.gov; SSTRANKO@dnr.state.md.us; Reynolds.Louis@epa.gov; Jcummins@ICPRB.org; msoutherland@Versar.com; abecker@dnr.state.md.us; Jai.Cole@montgomeryparks.org; cpoukish@mde.state.md.us; borsuk.frank@epa.gov; Mack, Kenny; JKilian@dnr.state.md.us; St. John, Jennifer; Van Ness, Keith; cgougeon@dnr.state.md.us; Naibert, Eric; Jackson.Susank@epa.gov; Shofar, Steven; Curtis, Meosotis; mary.dolan@montgomeryplanning.org; mark.symborski@montgomeryplanning.org; Forren.John@epa.gov; DBOWARD@dnr.state.md.us
Cc: Gerritsen, Jeroen
Subject: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

Hello everyone,
If your schedule permits, we'd greatly appreciate it if you could review the draft BCG report for the Northern Piedmont region of Maryland and provide comments (the report was sent out in a June 12 email – please let me know if you need me to resend it).

If possible, we ask that you provide comments by **Friday July 11th**.

Thank you for your participation, and have a great 4th of July holiday!

Jen

Jen Stamp | Aquatic Ecologist
Voice: 802.229.4508 (office) 802.839.8603 (cell)| Fax: 802.223.6551 Jen.Stamp@tetratech.com

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Jackson, Susank

From: Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent: Monday, July 21, 2014 10:35 AM
To: Jen.Stamp@tetratech.com; Mack, Kenny; Pond, Greg
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: RE: sub-sampling

Hi Jen:
Yes, please send the tool and instructions! Thank you so much. Always trying to improve our monitoring program.
Keith

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Friday, July 18, 2014 5:11 PM
To: Mack, Kenny; Pond, Greg; Van Ness, Keith
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: sub-sampling

Hi Greg, Keith and Ken,
Sorry for the delay in getting back to you about the subsampling question.
I looked back through the data and found 4 instances where both full and sub-sampled samples were assessed (see table below). Overall, there is good correspondence between the BCG calls. In one instance (LRTB203C), the calls differed by 1 BCG level, with the full sample getting a 6+ and the sub-sampled a 5.

Keith and Ken, if you are interested, I have a simple tool that I could send you that sub-samples to a specified total number of organisms. If it's something that you'd be interested in experimenting with, let me know and I'll write up some instructions and send it your way.

SITEYR	Exercise ID	Collection Date	Waterbody Name	Area (mi2)	Panelist consensus			BCG model - primary	Total Individuals
					Final	Best	Worst		
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Thanks! Have a great weekend,

Jen

From: Mack, Kenny [mailto:Kenny.Mack@montgomerycountymd.gov]
Sent: Tuesday, July 08, 2014 8:52 AM

To: Pond, Greg; Stamp, Jen
Cc: Van Ness, Keith; Jackson, Susank; Gerritsen, Jeroen
Subject: RE: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

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Jackson, Susank

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Sent: Monday, July 21, 2014 10:39 AM
To: Pond, Greg; Jen.Stamp@tetratech.com; Mack, Kenny
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: RE: sub-sampling

Hi Greg:

This has been a huge learning curve for me and my DOS 386 brain. It appears that I learn each time I read one of your emails or listen to you. I really never thought of the reasons why the BCG would be as comparable – it is a great relief that it is but getting our subsamples down to a reasonable size should help as well.
Thanks
Keith

From: Pond, Greg [mailto:Pond.Greg@epa.gov]
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Later this week is fine!

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Thanks Greg! Good insights. Having BCG rules based on relative abundance measures definitely helps when there are sub-sampling differences like this.

It sounds like you have the same program that I was going to pass along to them (the DOS-based Fortran subsample.exe program). Keith and Ken – I'll write up some quick instructions and will try and get that to you later this week.

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That is good news Greg!

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Keith, Ha! DOS 386. Funny.
Your biomonitoring program does not need to change subsample size (programmatically), but now you will have a method to computer subsample them easily for BCG purposes. It's analogous to randomly picking grids from trays, but does it in the computer (even DOS!). It does take a couple of extra steps (and I would do it all at once for each year's set of samples), but the upside is that you won't need to change your lab processing protocols if you don't want to.

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This has been a huge learning curve for me and my DOS 386 brain. It appears that I learn each time I read one of your emails or listen to you. I really never thought of the reasons why the BCG would be as comparable – it is a great relief that it is but getting our subsamples down to a reasonable size should help as well.
Thanks
Keith

From: Pond, Greg [mailto:Pond.Greg@epa.gov]
Sent: Saturday, July 19, 2014 8:02 AM
To: Jen.Stamp@tetratech.com; Mack, Kenny; Van Ness, Keith
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: RE: sub-sampling

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Thanks again for checking these. Please send me your program for subsampling too (I use a DOS-based Fortran method from Chuck Hawkins[subsample.exe], but I know it can be done in a variety of platforms).

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Sent: Friday, July 18, 2014 5:11 PM
To: Mack, Kenny; Pond, Greg; Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov> (Keith.VanNess@montgomerycountymd.gov)
Cc: Jackson, Susank; Gerritsen, Jeroen
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LPAT201b_2010	Samp026	4/29/2010	Aitchinson Trib.	0.92	3	3	3-	3	120
LRTB203C_2012	Samp011	4/16/2012	Turkey Branch	3.80	6+	5-	6	5	223
LRTB203Cb_2012	Samp030	4/16/2012	Turkey Branch	3.78	5	5	6	5	120
LSTM110_2012	Samp001	3/29/2012	King Spr	0.30	3+	2	3	3	150
LSTM110b_2012	Samp031	3/29/2012	King Spr	0.33	3-	3+	4+	3	120
NWBP205_2011	Samp020	3/14/2011	Bel Pre	3.60	5	4-	5	5	239
NWBP205b_2011	Samp036	3/14/2011	Bel Pre	3.61	5	5	6+	5	120

Thanks! Have a great weekend,

Jen

From: Mack, Kenny [mailto:Kenny.Mack@montgomerycountymd.gov]
Sent: Tuesday, July 08, 2014 8:52 AM
To: Pond, Greg; Stamp, Jen
Cc: Van Ness, Keith; Jackson, Susank; Gerritsen, Jeroen
Subject: RE: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

Thanks for getting back to me so quickly Greg. My practical concern stems from utilization of the BCG to assess our data set. Almost half our samples contain greater than 150 individuals. The number of individuals will have to be a consideration as we run our data.

Thanks,

Ken Mack
Aquatic Biologist
Montgomery County
Department of Environmental Protection
255 Rockville Pike,
Rockville, MD 20850
240-777-7729

From: Pond, Greg [mailto:Pond.Greg@epa.gov]
Sent: Monday, July 07, 2014 5:19 PM
To: Mack, Kenny; Jen.Stamp@tetratech.com
Cc: Van Ness, Keith; Jackson, Susank; Gerritsen, Jeroen
Subject: RE: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

Thank you Kenny for these observations. I had sent Jen comments earlier that changed the wording on this in the methods section to recognize 100-150 organisms. In the second workshop, we did re-assess sites using 120 that previously had sometimes >300 organisms, to see if panelists would change their assessment. I don't believe we had a sample size of sites worth analyzing statistically but we did this for observational purposes only. The 120 computer subsample of MoCo data was absolutely necessary to strike a balance between MBSS and MoCo datasets. There were some samples that had >150, but I believe these were re-do's and I'm not sure they count, but Jen and Jeroen could confirm. To answer your question, I do not believe tiers would be correlated with increasing number of individuals, since the samples came from a variety of conditions (good, bad, ugly). That said, I wonder if it is worthwhile addressing those several samples in a paragraph that the panel re-assessed with the 120 standard subsample. My memory is that they did not change for nominal assignments but might have changed to a (+) or (-) within a tier ....

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Sent: Monday, July 07, 2014 3:05 PM
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Cc: Van Ness, Keith; Pond, Greg; Jackson, Susank; Gerritsen, Jeroen
Subject: RE: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

Hi Jen,

Sorry I didn't get back to you sooner, but I have had a chance to review the report and have two comments:

1) Jai Cole, Matt Harper, and Dave Sigrist work for *Maryland National Capital Park and Planning Commission* or *MNCPPC* (Page ii)

2) "The macroinvertebrate BCG model outputs should be interpreted with caution and checked using professional assessment if: 1) samples are collected early or late in the index period; 2) if levels of taxonomy are inconsistent with those used in the calibration dataset (e.g., if Chironomidae are not identified to the subfamily or tribe-level); and 3) if there are more than 120 total individuals in the sample."

Was macroinvertebrate tier assignment correlated to number of individuals in the sample? After quickly glancing at the validation files it appears almost half of the sites assessed had more than 120 individuals, and those with 120 individuals contain only a subset of the original sample. In the discussion section (end of first paragraph on page 33) it says additional caution must be taken when a sample contains greater than 120 individuals. When should a subset of 120 individuals be used in place of the original sample? Were samples that were subsampled to 120 individuals found to have different tier assignments than those that were not reduced to 120 individuals?

Thanks,

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From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Wednesday, July 02, 2014 1:30 PM
To: Pond.Greg@epa.gov; EFriedman@dnr.state.md.us; Warren.Smigo@deq.virginia.gov; William.Shanabruch@deq.virginia.gov; Ellen.Dickey@state.de.us; mstover@mde.state.md.us; mbaker@umbc.edu; NDziepak@dnr.state.md.us; Matthew.Harper@montgomeryparks.org; David.Sigrist@montgomeryparks.org; aeverett@pa.gov; cluckett@mde.state.md.us; Jeanne.Classen@deq.virginia.gov; aleslie@umd.edu; cmswan@umbc.edu; agriggs@icprb.org; Jordahl, Dave; Alexander.Laurie@epa.gov; SSTRANKO@dnr.state.md.us; Reynolds.Louis@epa.gov; Jcummins@ICPRB.org; msoutherland@Versar.com; abecker@dnr.state.md.us; Jai.Cole@montgomeryparks.org; cpoukish@mde.state.md.us; borsuk.frank@epa.gov; Mack, Kenny; JKilian@dnr.state.md.us; St. John, Jennifer; Van Ness, Keith; cgougeon@dnr.state.md.us; Naibert, Eric; Jackson.Susank@epa.gov; Shofar, Steven; Curtis, Meosotis; mary.dolan@montgomeryplanning.org; mark.symborski@montgomeryplanning.org; Forren.John@epa.gov; DBOWARD@dnr.state.md.us
Cc: Gerritsen, Jeroen
Subject: seeking comments on draft BCG report for the Northern Piedmont region of Maryland

Hello everyone,
If your schedule permits, we'd greatly appreciate it if you could review the draft BCG report for the Northern Piedmont region of Maryland and provide comments (the report was sent out in a June 12 email – please let me know if you need me to resend it).

If possible, we ask that you provide comments by **Friday July 11th**.

Thank you for your participation, and have a great 4th of July holiday!

Jen

Jen Stamp | Aquatic Ecologist
Voice: 802.229.4508 (office) 802.839.8603 (cell)| Fax: 802.223.6551 Jen.Stamp@tetratech.com

Tetra Tech | Complex World, Clear Solutions

73 Main Street, Suite 38 | Montpelier, VT 05602 | www.ttwater.com | NASDAQ:TTEK

Jackson, Susank

From: Van Ness, Keith <Keith.VanNess@montgomerycountymd.gov>
Sent: Wednesday, July 30, 2014 9:46 AM
To: Jen.Stamp@tetratech.com; Pond, Greg; Mack, Kenny
Cc: Jackson, Susank; Gerritsen, Jeroen; Curtis, Meosotis
Subject: RE: sub-sampling

Hi Jen:
No worries – looks like I forgot something as well. I am retiring from government service. I have put in about 31 years and it's time to let some young whippersnapper take over. Today is my last day and then I will truly be 'Old Man River'. Completing the BCG was the last on my bucket list – when you are ready please send it to Ken and Meo. We are looking forward to applying it to our data. It was remarkable to have been able to work with all of you and see the difference good science can make. I am not leaving the area so feel free to email me at cobble123@verizon.net. Ken and Meo also know how to find me.

Susan – when you need more benthic macroinvertebrates – just ask Ken. We owe you several buckets of critters by now.

Take care
Keith

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Wednesday, July 30, 2014 9:37 AM
To: Van Ness, Keith; Pond, Greg; Mack, Kenny
Subject: RE: sub-sampling

Hi Keith, Greg and Ken,
I apologize for the delay in sending you the subsampling program and instructions. I have not forgotten – I just got tied up with some other things. I hope to be in touch with it soon.
Thank you for your patience!

Jen

From: Van Ness, Keith [mailto:Keith.VanNess@montgomerycountymd.gov]
Sent: Monday, July 21, 2014 10:39 AM
To: Stamp, Jen; Pond, Greg; Mack, Kenny
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: RE: sub-sampling

Later this week is fine!

From: Stamp, Jen [mailto:Jen.Stamp@tetratech.com]
Sent: Monday, July 21, 2014 10:19 AM
To: Pond, Greg; Mack, Kenny; Van Ness, Keith
Cc: Jackson, Susank; Gerritsen, Jeroen
Subject: RE: sub-sampling

Thanks Greg! Good insights. Having BCG rules based on relative abundance measures definitely helps when there are sub-sampling differences like this.

It sounds like you have the same program that I was going to pass along to them (the DOS-based Fortran subsample.exe program). Keith and Ken – I'll write up some quick instructions and will try and get that to you later this week.

Thanks,

Jen

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Tetra Tech | Complex World, Clear Solutions

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